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COVER: Soaring Peregrine Falcon (*Falco peregrinus*). Oil painting by Dick Dekker.

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PEREGRINE FALCON PREDATION ON DUNLINS AND DUCKS AND KLEPTOPARASITIC INTERFERENCE FROM BALD EAGLES WINTERING AT BOUNDARY BAY, BRITISH COLUMBIA

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ABSTRACT.—At Boundary Bay, British Columbia, wintering Peregrine Falcons (*Falco peregrinus*) captured 94 Dunlins (*Calidris alpina*) in 652 hunts. The major hunting techniques were open attacks on flying flocks (62%) and stealth attacks on feeding or roosting flocks (35%). Success rates for these techniques were 9.1% and 23.6%, respectively. Sixty-five Dunlins were taken directly from the edge of flocks; 29 Dunlins were seized after they had split off from flocks or were flying alone. Adult peregrines were significantly more successful than immatures (26.8% vs. 9.0%). Peregrines captured one Green-winged Teal (*Anas crecca*) and three larger ducks. The teal was carried away, but the larger ducks were pirated by Bald Eagles (*Haliaeetus leucocephalus*). Eagles often joined peregrines that were chasing Dunlins; six eagles succeeded in either capturing the Dunlin or forcing a peregrine to drop its just-caught prey. It is postulated that peregrines wintering at Boundary Bay avoid prey species that are too heavy to be carried out of reach of kleptoparasitic eagles. Female peregrines aggressively chased off other females, but they tolerated males. Females often joined males that were chasing Dunlins; 14 males were forced to surrender their prey to females. Four peregrines pirated Dunlins from Merlins (*Falco columbarius*).

KEY WORDS: *Bald Eagle*, *Haliaeetus leucocephalus*; *Dunlin*, *Calidris alpina*; *Peregrine Falcon*, *Falco peregrinus*; *British Columbia coast*; *ducks*; *hunting habits*; *kleptoparasitism*.

PREDACIÓN DEL HALCÓN PEREGRINO SOBRE CHORLITOS Y PATOS, E INTERFERENCIA KLEPTOPARASITICA DEL AGUILA CALVA TEMPERANDO EN LA BAHIA DE BOUNDARY, BRITISH COLUMBIA

RESUMEN.—En sitios de destinacion final de la migración de otoño, el halcón peregrino (*Falco peregrinus*) capturó 94 chorlitos (*Calidris alpina*) en 652 cacerías/persecuciones, en la Bahía de Boundary, British Columbia. Las técnicas de cacería más sobresalientes fueron ataques abiertos sobre parvadas al vuelo (62%) y ataques furtivos sobre parvadas forrajeando o perchando (35%). Las tasas de éxito para esta técnicas fueron 9.1% y 23.6%, respectivamente. Sesenta y cinco chorlos fueron tomados directamente del borde de la bandada; 29 chorlitos fueron atrapados después de haberse separado de la bandada o estaban volando solos. Los peregrinos adultos fueron significativamente más exitosos que los inmaduros (26.8% vs. 9.0%). Los peregrinos capturaron un pato aliverde (*Anas crecca*) y tres patos más grandes. El pato aliverde fue llevado/apartado, pero el pato grande fue robado por aguilas calvas (*Haliaeetus leucocephalus*). Las águilas a menudo se unen a los peregrinos que están persiguiendo chorlitos; seis águilas tuvieron éxito, ya sea capturando chorlitos o forzando a los peregrinos a soltar su recién atrapada presa. Se ha postulado que los peregrinos que temperan en la Bahía de Boundary evitan especies de presas que son demasiado pesadas para ser llevadas fuera del alcance de águilas kleptoparasíticas. Las hembras de peregrino persiguen agresivamente otras hembras, pero toleran a los machos. Las hembras a menudo se unieron a los machos que estaban cazando chorlitos; 14 machos fueron forzados a ceder su presa a las hembras. Cuatro peregrinos robaron los chorlitos a los esmerejones (*Falco columbarius*).

[Traducción de César Márquez]

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In their nearly worldwide range, Peregrine Falcons (*Falco peregrinus*) prey on a wide variety of birds, although they may locally specialize on very few species (Brown and Amadon 1968, Palmer 1988). The size of the prey taken is partly determined by the sex of the peregrine because females are about one-third heavier than males. This sexual size-dimorphism has spawned several hypotheses, including that it widens the range of prey that can be taken by paired falcons (Selander 1966, Cade 1982). Although both sexes of peregrines may hunt the same prey species, such as the Rock Dove (*Columba livia*) in human-altered ecosystems (Ratcliffe 1993, Frank 1994), or murrelets (*Brachyramphus* spp.) over the ocean (Beebe 1960, Dekker and Bogaert 1997), in many habitats female peregrines tend to kill larger prey than do males. For example, in central Alberta, migrant female peregrines predominantly killed ducks (Anatidae), while the males took sandpipers (Scolopacidae) and small passerines (Dekker 1980, 1988). Peregrines wintering in coastal agricultural regions of British Columbia and Washington also partitioned the food resource by gender (Anderson and DeBruyn 1979, Dekker 1987, 1995, 1999).

In the estuaries of western North America, a common prey of wintering peregrines is the Dunlin (*Calidris alpina*). Based on the remains of Dunlins killed by falcons, researchers in Washington and California reported that the majority are juveniles, which might be related to age-related flocking behavior (Kus et al. 1984, Warnock 1994). This paper details the hunting methods of both sexes of peregrines attacking flocks of Dunlins. It also reports on the duck hunting habits of these peregrines with particular reference to kleptoparasitic interference from Bald Eagles (*Haliaeetus leucocephalus*).

STUDY AREA AND METHODS

The study area is at Boundary Bay, which is part of the Fraser River delta (49°05'N, 123°00'W) in southwestern British Columbia. The bay is 16 km across and the intertidal zone is roughly 4 km wide at the lowest ebb. The tidal mud flats are bordered by a narrow strip of salt-marsh and a dyke that protects low-lying agricultural fields inland. Boundary Bay is a major stop-over for migratory waterbirds and a wintering refuge for ca. 20 000 ducks and 50 000 Dunlins. The only other shorebird to winter in the bay in some numbers (ca. 1000) is the Black-bellied Plover (*Pluvialis squatarola*) (Butler 1994, Butler and Kaiser 1995). Bald Eagles are common year-round and increase locally to 50–150 during January–February (Dekker 1999). For a more detailed description

of the Fraser delta and its avifauna, see Butler and Campbell (1987).

Between early November and early February, 1994–2003, I spent part or all of 151 d in the study area for a total of 940 hr. I walked the dyke or, especially during rain and strong winds, sat in a parked vehicle at a vantage point from where the tide flats were visible. To study the interaction of peregrines and their prey species, I used three principal methods: (1) flocks of ducks and shorebirds were monitored for alarm behavior such as sudden flushing; (2) the area was frequently scanned through binoculars to spot flying peregrines; and (3) perched peregrines were observed for varying lengths of time in the hope of seeing them hunt.

Peregrines were classified as either adult or immature, based on dorsal color and ventral markings (Palmer 1988). Males and females could only be separated with certainty, respectively, at the lower or higher end of their size range, because recorded weights of the heaviest male peregrines overlap with those of the lightest females, particularly between the subspecies occurring in western North America (Brown and Amadon 1968, White et al. 2002). Some falcons appeared typical of *F. p. pealei* (Beebe 1960), others of *F. p. anatum* (Palmer 1988). There is no evidence that peregrines of arctic origin (*F. p. tundrius*) winter in the bay. Already by the second week of February sightings of peregrines dropped off sharply, perhaps indicative of a return to breeding sites in the region.

Data were recorded in diary form and entered into an annotated table of hunts and kills. The term “hunt” is defined as a completed attack of which the outcome was known (Dekker 1980, 1988). A hunt could include one or more passes or stoops at the same Dunlin or flock. An attack on a flock and subsequent pursuit of a single Dunlin fleeing that flock were counted as one hunt. However, if the peregrine abandoned the pursuit and presently made another attack on the same or a different flock, this was counted as a second hunt. This definition of a hunt is equivalent to the term “attack” used by Cresswell (1996), but differs from “hunting flight” as formulated by Buchanan et al. (1986) and Buchanan (1996). Whether or not a hunt resulted in a kill was not always immediately apparent, especially at distances of >1 km. If the falcon ended a hunt by flying away fast and attacking other birds, without having been chased by a kleptoparasite, the preceding hunt was unsuccessful. On the other hand, if the falcon briefly slowed down with lowered feet, or if it retrieved something from the ground or water, then headed directly to shore, it was probable that prey had been caught. Supporting clues were pursuit by conspecifics, eagles or large gulls (*Larus* spp.). However, all probable captures were deleted from the data base unless they could be confirmed; for instance, by feeding activity. Perched peregrines were viewed through a 20–60 power telescope. Separate success rates were computed for adults and immatures and for the major strategies. Hunting data collected in 1994–98, which were presented in an earlier paper (Dekker 1998), were analyzed further and added to the data obtained in 2000–03. Data sets were compared statistically by G-test of independence (Sokal and Rohlf 1969).

Table 1. Success rates of various strategies used by Peregrine Falcons hunting Dunlins at Boundary Bay, British Columbia.

METHOD	HUNTS	KILLS	% SUCCESS
Stealth hunts	229	54	23.6
Open hunts	406	37	9.1
Unknown method	17	3	17.6
Totals	652	94	14.4

RESULTS

Dunlin Hunts. In hunting Dunlins, peregrines used two main methods: a low stealth attack on resting or feeding flocks, or an open attack on flying flocks. The stealth approach was used in 35% of hunts and resulted in 57% of total kills. The success rate of stealth hunts was significantly higher ($G = 17.53, P < 0.0001$) than open hunts (Table 1). Low stealth attacks were launched from perches or flapping flight, rarely by a stoop from high soaring flight. The Dunlins usually flushed at the very last moment and the peregrine might immediately

succeed in seizing its prey. Often one or more Dunlins dodged the falcon by dropping back onto the mud or water. Most took off at once with the peregrine occasionally pursuing them again. Others failed to rise and appeared to have been hit by the falcon. These prey, either crippled or dead, were retrieved in an unhurried pass by the peregrine.

In 62% of hunts, the falcons attacked Dunlins that had flushed well ahead or that were already airborne over the mudflats or ocean. If the approaching peregrine flew >10 m high, the Dunlins formed dense, globular flocks over the ocean. (See Buchanan et al. 1988.) In the deciding stage of attacks on aerial flocks, individual peregrines differed in method. They commonly maneuvered for position above the spherical flock until they stooped perpendicularly with rigid wings, either held open or tucked in. From a distance, it might seem as if some falcons plunged right through the massed Dunlins. This could never be verified. Instead, the falcon often skirted the outside edge of the flock. At the terminus of its stoop, the peregrine typically drew level and attacked the bottom end of the flock (Fig. 1a). Other peregrines

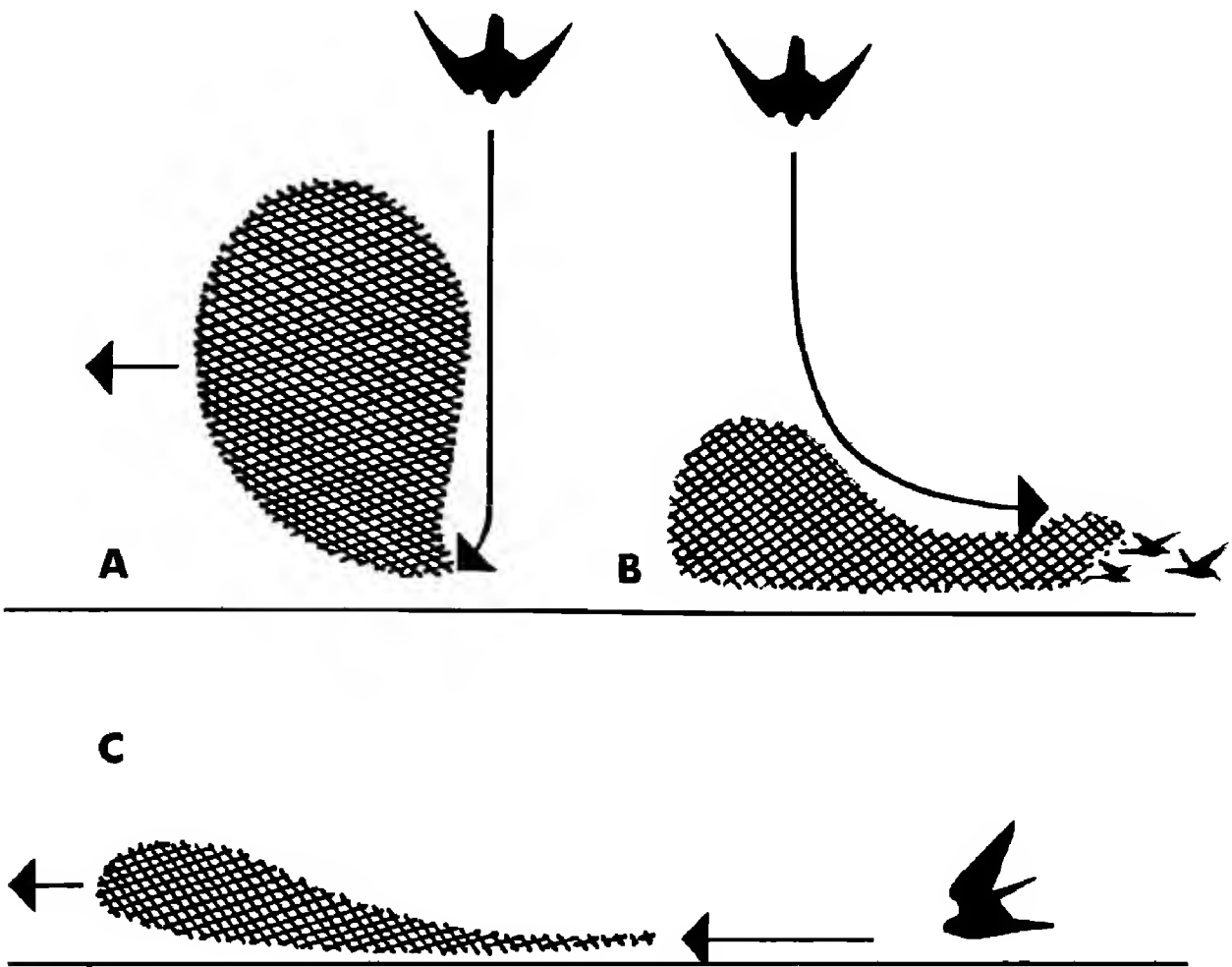


Figure 1. Strategies used by peregrines in attacks on flocks of Dunlins. The prey is either taken from the bottom, the edge, or the tail end of the flock. A. The peregrine stoops alongside of the flock and aims for the bottom B. The peregrine stoops directly at the flock, which “caves in” and flattens out low over the water. C. Pursuit of flushing or low-flying flock.

stooped straight at the flock, which reacted by “caving in” and flattening out over the water while the falcon raked low over them (Fig. 1b). One or more Dunlins might splash down and take off again. Others may have been hit by the falcons. If the falcon failed to seize its prey at once, it either: (1) pursued a single Dunlin that split away from the flock; (2) regained altitude and maneuvered for another vertical stoop at the same flock; (3) attacked a different flock some distance away; or (4) ended the hunting sequence by perching or flying away.

In stealth hunts, when the peregrine approached in low flight (<1 m), flocks of Dunlins that flushed ahead might stay low as well, particularly during stormy weather when they commonly flew very low over the waves. If attacked and overtaken by a falcon, Dunlins in the trailing end of the low-flying flock could be seized (Fig. 1c). Single birds that dodged by dropping into the water and taking off again might be pursued and swooped at with varying degrees of persistence. Twenty-seven Dunlins were captured after individual pursuit including 3–10 passes. Two lone Dunlins, flying at 20–25 m, were seized by immature male peregrines that stooped nearly perpendicularly from a height of >100 m. In three separate, but unsuccessful instances, immature peregrines persisted in follow-chasing Dunlins >100 m high and far inland. After dodging 20–40 swoops, all three Dunlins descended and escaped into bushes.

The main hunting methods of stealth and open attack were used by all peregrines, although open attacks on flying flocks with multiple stoops appeared to be more typical of males than females. Immature males could be very persistent, but quite unsuccessful. For instance, on 21 January 2003, an immature male failed to make a capture over a period of 2.5 hr during which he launched three series of attacks over the low tide line, including a total of about 30 stoops at flocks. On 24 and 25 January 2003, an immature male made 22 and 33 consecutive stoops at flying flocks respectively, all without success. By contrast, on 11 November 2002, an adult male captured two Dunlins 20 min apart, each requiring only one stealth attack on roosting flocks. Of the total 652 hunts directed at Dunlins, 25% were made by adult peregrines, yet they accounted for 47% of the kills (Table 2). The success rate of adults was 26.8%, significantly higher than the 9.0% rate of immatures ($G = 19.92, P = <0.0001$).

Table 2. Success rates of Peregrine Falcons hunting Dunlins in British Columbia, and comparison with other studies of peregrines hunting shorebirds.

	HUNTS	KILLS	% SUC- CESS
This study (seacoast, winter)			
Adults	164	44	26.8
Immatures	399	36	9.0
Unidentified	89	14	15.7
Totals	652	94	14.4
Scotland ^a (seacoast, winter)	233	25	10.7
Alberta ^b			
(Prairie Lake, migration times)	569	50	7.2

^a Cresswell 1996.

^b Dekker 1988.

Unless they were hunting, adult males appeared to spend little time in the study area. On the other hand, adult females often perched for hours in the salt marsh or on inland cultivated land. On most days, two different adult females perched ca. 3 km apart. Evidently territorial, they attacked and chased off other females, either adult or immature. By contrast, the females tolerated males, and often joined them in attacking flocks of Dunlins. Frequently, both sexes pursued the same Dunlin, which might be captured by either one. However, if the male made the capture, he was chased and robbed by the female. Fourteen males dropped their prey, others were pursued far away and out of sight. Probably to avoid piracy by conspecifics, some male peregrines, upon capturing a Dunlin, flew to forested headlands across the bay. Four males circled to a high altitude and consumed their prey on the wing. The peregrines also robbed four Merlins (*Falco columbarius*) of their freshly-caught Dunlins. Peregrines hunted Dunlins throughout the day; 46 kills were made prior to 1200 H and 48 after 1200 H. The respective values for kills per hour of observation (1/8.1 and 1/12.4) were not significantly different ($G = 2.85, P > 0.05$). Peregrines often resumed hunting immediately after eating a Dunlin, which took 10–20 min.

Duck Hunts. The peregrines rarely hunted ducks in the study area. Only four kills were seen. A Green-winged Teal (*Anas crecca*), that was flushed and briefly pursued by an adult male, was seized in a shallow pool on the edge of the salt marsh.

The peregrine carried his prey out of sight low over the marsh. Female peregrines pursued and captured three ducks larger than teal, presumably Northern Pintails (*Anas acuta*), which were seized on the ground after the ducks dodged the approaching falcon by dropping onto the wet tide flats.

Kleptoparasites. All three large ducks captured by peregrines in the study area were forfeited without a fight to approaching Bald Eagles. Four other peregrines that chased and harassed ducks for some distance were shadowed by one or more Bald Eagles, which attempted to seize ducks that dodged the peregrine by ditching into the water. Eagles also commonly interfered with peregrines that were hunting Dunlins. At least 50 of 94 peregrines, which had just caught Dunlins, were immediately pursued by one or more eagles. The falcons usually managed to stay ahead of eagles. However, three peregrines, closely harassed by 2–4 eagles, released their Dunlins. Two of these falling prey items were retrieved in mid-air by one of the eagles. In at least three cases, eagles pounced on and captured Dunlins that had ditched into the water or dropped into grassy vegetation to dodge the falcon.

The following incident is a typical example of intra- and interspecific competition between falcons and eagles. In the afternoon of 16 January 2003, a male peregrine stooped at a flock of Dunlins and pursued a single bird that split off and dodged repeated passes. The male was quickly joined by a female peregrine and four eagles. All of these alternately swooped at, or tried to swoop at the Dunlin which flew erratically 1–10 m high over the water. After a combined total of 10–12 passes, the Dunlin was caught by the female peregrine, which was immediately set upon by the eagles. The peregrine managed to escape and carry her prey far inland. Prey-carrying peregrines were frequently, but vainly, chased by Glaucous-winged Gulls (*Larus glaucescens*). In addition, gulls often joined peregrines that were pursuing lone Dunlins, and on two occasions gulls pounced on Dunlins that had ditched into the water to escape a swooping peregrine.

DISCUSSION

The stealth tactics used by the falcons in this study were similar to those reported for migrating peregrines hunting shorebirds in central Alberta, although, due to more favorable weather condi-

tions, the migrant falcons launched their stealth attacks more often from high soaring flight (Dekker 1980, 1988, 1999). The percentage of stealth hunts in the two studies is, however, quite different (35% at Boundary Bay vs. 77% in Alberta). The explanation can be found in the difference in respective habitats. The Alberta falcons hunted over reed-studded shallows of a large inland lake, which afforded ample opportunities for a concealed approach. By contrast, the relatively low use of stealth on the coast of British Columbia reflects the lack of opportunity for effective surprise over the tide flats. The percentage of stealth hunts in this study is nearly equivalent to the 36% reported from the east coast of Scotland (Cresswell 1996).

It is possible that stealth hunts, especially successful ones by adult peregrines, are under-recorded in this study, resulting in a bias in favor of open hunts. Successful stealth attacks on flocks of Dunlins roosting near the salt marsh easily escape detection by the human observer. Stealth attacks are often initiated from distances of >1 km and the terminal portion takes place very low over the ground or water. The light-colored plumage of the adult falcon blends into the background of water and renders it more difficult to detect than a dark immature peregrine. Screened by the massive flushing of hundreds or thousands of Dunlins, the attacking peregrine might carry its prey away before the observer is aware of what happened. Adult falcons are competent in the use of stealth and especially the male tends to keep a low profile, perhaps to avoid attracting the attention of kleptoparasites.

In contrast to stealth attacks, open hunts are readily observed because the observer is alerted to the arrival of the predator by the rising of dense flocks of Dunlins. However, during a prolonged series of attacks, it is difficult to keep accurate score of the exact number of falcon hunts. Stoops on flocks can follow each other in rapid succession and the observer often cannot determine if a stoop was aimed at the same or a different flock. To avoid this problem, Buchanan et al. (1986) used the term hunting flight, which is defined as “a perch to perch flight involving one or more capture attempts.” Although the number of kills was very small ($N = 7$), Buchanan et al. (1986) calculated the success rate of hunting flights as 47% and that of individual capture attempts as 14.6%.

Any study of the hunting habits of the Peregrine Falcon involves a certain amount of subjective in-

terpretation, which might in part explain the variance between studies (White et al. 2002). In my appraisal of open hunts, I kept score of separate attacks in a conservative way, concentrating on the outcome. How the kill was made seemed of more importance than how often the falcon missed. Many hunts that fail may not be all that intense. This possibility was pointed out by Treleven (1980), who coined the terms high-intensity and low-intensity hunting.

Based on the examination of prey remains, a high proportion of shorebirds killed by raptors were reported to be juveniles (Whitfield 1985, War-nock 1994). Kus et al. (1984) suggested that this may be due to age-related differences in Dunlin flocking behavior. I postulate that the mechanics of prey selection may be very simple. Sixty-five (69%) of the Dunlins captured during this study were taken from the outside or the tail end of flocks (Fig. 1). Flocking is a well-known predator avoidance behavior of open-country birds. Their drawing together into dense aerial formations is the result of each bird's instinctive desire to find safety in the center of the flock (Tinbergen 1951). I speculate that adults are more proficient at this than juveniles, which are left on the outside of the flock. Several studies have reported age-related segregation of birds in roosting and feeding flocks (Newton 1998). If peregrines selectively remove juvenile Dunlins from a wintering population because they are easier to capture than adults, then the proportion of vulnerable juveniles in that population should decline over the course of the winter. Furthermore, juveniles that are attacked on a daily basis and manage to survive for several months, might learn to become more vigilant and avoid capture. These conclusions seem to be supported by the data. The respective hunting success rates of peregrines for November and January decline from 18.6% ($N = 134$) to 12.4% ($N = 404$), although the difference is not significant ($G = 2.30$, $P > 0.05$).

The kleptoparasitic habits of Bald Eagles are well known, particularly at the expense of peregrines that hunt ducks or seabirds (Anderson and DeBruyn 1979, Dekker 1995, Dekker and Bogaert 1997). Bald Eagles also kleptoparasitize Merlins. During this study, Merlins were seen to capture 14 Dunlins, two of which were pirated by pursuing eagles. Buchanan (1988) reported similar instances and he suggested that the threat of losing prey to a kleptoparasite resulted in Merlins engaging in

hunting flights of shorter duration when potential kleptoparasites were present. Gyrfalcons (*Falco rusticolus*) wintering in Alberta were often robbed of ducks by eagles as well and avoided hunting at localities where Bald Eagles sat on prominent perches (Dekker and Court 2003).

In conclusion, I suggest that the ubiquitous presence of eagles at Boundary Bay discourages wintering peregrines from hunting ducks on the tide flats. The possibility exists that peregrines may hunt ducks more often at night or at inland localities where eagle presence is lower than on the coast. Adult female peregrines, which had perched on the coast for much of the day, flew inland at dusk when ducks also leave the coast to feed on inland meadows (Dekker 1999). During November, when eagles are far less numerous at Boundary Bay than in January, several immature peregrines hunted ducks persistently in the study area. As the winter progresses however, I surmise that these juveniles eventually stop hunting ducks on the tide flats and instead concentrate on prey such as the Dunlin that can easily be transported over long distances, out of reach of kleptoparasitic eagles.

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THE 2000 CANADIAN PEREGRINE FALCON SURVEY

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ABSTRACT.—National surveys for Peregrine Falcons (*Falco peregrinus*) have been conducted in Canada every five years since 1970. This paper discusses the results of the seventh such survey. In 2000, 22 areas in nine provinces and three territories were searched for three peregrine subspecies. Within the continental *F. p. anatum* range, 374 sites were occupied by territorial peregrines. As in previous surveys, the majority of *anatum* sites were located in the western boreal ecoregion. However, numbers are increasing in populations south of 58°N. The number of *F. p. tundrius* in 2000 was similar to previous surveys at Rankin Inlet, Nunavut and Tuktut Nogait National Park, Northwest Territories. Nine sites occupied on the North Slope of the Yukon Territory is a slight increase in this *tundrius* subgroup. Coastal *F. p. pealei*, on the Queen Charlotte Islands appear to have been stable for at least the past two decades. *Pealei* numbers on the north shore of Vancouver Island and the surrounding area were substantially higher in 2000—largely the result of a more extensive search effort. Reproductive output in 2000 was 1.0 or more young/territorial pair, except in the *anatum* subpopulations of northern Alberta and the Peel River, Yukon Territory where it was 0.7 and 0.6 young/territorial pair, respectively. Overall, with stable populations in the north and growing populations in the south, the peregrine recovery is well underway and in some areas, approaching historical size and probably ecological carrying capacity.

KEY WORDS: *Peregrine Falcon*; *Falco peregrinus*; *status*; *survey*; *Canada*; *reproductive output*.

PROSPECCION DEL HALCÓN PEREGRINO CANADIENSE EN EL 2000

RESUMEN.—Prospecciones nacionales del Halcón Peregrino (*Falco peregrinus*) han sido llevadas a cabo en Canadá cada 5 años desde 1970. Este artículo discute los resultados de la séptima inspección. En el 2000, 22 áreas en nueve provincias y tres territorios fueron monitoreados para tres subespecies de peregrino. Dentro del rango continental de *F. p. anatum*, 374 sitios fueron ocupados por peregrinos territoriales. Al igual que en prospecciones previas, la mayoría de los sitios de *anatum* estuvieron localizados en la ecoregión boreal del oeste. Sin embargo, los números se están incrementando en las poblaciones al sur de 58°N. El número de *F. p. tundrius* en el 2000 fue similar al de surveys previos en Rankin Inlet, en los parques nacionales de Nunavut and Tuktut Nogait de los territorios del Noroeste. Nueve sitios ocupados en la Pendiente norte del territorio de Yukón, es un incremento leve en este subgrupo *tundrius*. El costero *F. p. pealei*, en las Islas Queen Charlotte parece que han estado estables por al menos, las pasadas dos décadas. Los números de *pealei* en la costa norte de la Isla de Vancouver y en las áreas aledañas, fueron substancialmente más altas en el 2000—debido, en gran medida a un esfuerzo de búsqueda más extensivo. El rendimiento reproductivo en el 2000 fue de 1.0 o más par joven/territorio, excepto en la subpoblación de *anatum* en el norte de Alberta y en el Río Peel (Peel River), Territorio de Yukón donde fue de 0.7 y 0.6 par joven/territorio respectivamente. Globalmente, con poblaciones estables en el norte y poblaciones crecientes en el sur, la recuperación del peregrino es buena y en algunas áreas, se aproxima al tamaño histórico y probablemente a la capacidad de carga ecológica.

[Traducción de César Márquez]

Peregrine Falcons (*Falco peregrinus*) bred historically throughout most regions of Canada and are again breeding in many of these same regions to-

day. Three subspecies of peregrine occur in Canada (White 1968). Generally, the continental *anatum* subspecies breeds south of the treeline from the Atlantic to the Pacific oceans. The smaller, northern *tundrius* subspecies nests along arctic riv-

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ers, lakes, and coastline and inland escarpments. The larger, darker western *pealei* subspecies occupies coastal islands and areas of adjacent mainland British Columbia. The biology of Peregrine Falcons is described by Hickey (1969), Cade et al. (1988), Erickson et al. (1988), and Brown and Amadon (1989).

A decline in peregrine numbers in North America started in the late 1940s and continued up to the mid 1970s (Hickey 1969, Kiff 1988). This decline was linked directly to the contamination of peregrines by pesticides such as DDT, dieldrin, and heptachlor epoxide (Ratcliffe 1969, Risebrough and Peakall 1988). These chemicals occurred in eggs, carcasses and some prey species, causing death, eggshell thinning and breakage, and overall population decline. In response, in 1978 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classified *anatum* peregrines as endangered, *tundrius* as threatened, and *pealei* as rare (Martin 1979). Captive-breeding of Peregrine Falcons began in Canada in 1972, releases started in 1975 (Fyfe 1988), and the first captive-raised falcons bred in the wild in 1977 (White et al. 1990). In 1986, a Recovery Team was formed and in 1987 a Recovery Plan was approved (Erickson et al. 1988).

In Canada, researchers began surveying peregrines prior to 1960 (Beebe 1960, Enderson 1965, Fyfe 1969). From 1970 on, national surveys were carried out every 5 yr to determine nest site occupancy and reproductive rates. The 1965 Madison Peregrine Conference and the 1970 and 1975 North American surveys documented the continued downfall of the peregrine (Hickey 1969, Cade and Fyfe 1970, Fyfe et al. 1976). By 1980, numbers were low, but stabilizing in northern Quebec, the Northwest Territories, (including today's Nunavut Territory) and the Yukon. Only one site was occupied in the prairies and the boreal forest south of 58°N and east of the Rocky Mountains (White et al. 1990). Surveys on the Labrador coast in the mid-1980s identified a significant breeding population (Lemon and Brazil 1990). This population expanded to 31 known pairs by 1995. The release of 178 captive-raised young in the Maritimes between 1982 and 1991 (Sam et al. 1994) resulted in the return of this population to six pairs by 1995 (Amirault et al. in press).

By 1985–86, west coast and northern populations also had increased or were stable while in the south a small urban population was established by

the reintroduction of captive-raised young (Murphy 1990). Starting in the late 1980s, the releases of captive-raised young were made in fewer areas, with more young per release. The 1990 survey again documented stable or increasing northern and coastal populations with smaller gains made in the south (Holroyd and Banasch 1996). In 1992, COSEWIC reclassified *tundrius* as vulnerable (Bromley 1992). By 1995, stable or increasing survey numbers of *anatum* met the objectives set previously for six management zones across Canada (Erickson et al. 1988, Banasch and Holroyd in press). In 1999, *pealei* were retained as a species of special concern (COSEWIC 2000) and *anatum* were downlisted from endangered to threatened (Johnstone 1999).

The purpose of this paper is to present results of the 2000 national survey that documented the population status and reproductive output of Canada's Peregrine Falcons. By comparing these data with data from previous surveys, we can evaluate the success of past management actions, reevaluate status designations, continue to monitor the complete and successful recovery of this species, and determine what management actions are required in the future.

GENERAL METHODS

In 2000, the survey included a comparable number of sites with effort similar to previous 5-yr surveys such that population numbers and reproductive data could be compared with the past six national surveys. Although the focus of surveys was to visit historical nest sites, new sites found during and in-between 5-yr surveys were also included. Previous survey results were taken from Cade and Fyfe (1970), Fyfe et al. (1976), Court et al. (1988a), Munro and Van Drimmelen (1988), Murphy (1990), White et al. (1990), Holroyd and Banasch (1996), and Banasch and Holroyd (in press). As with all surveys, however, there are some limitations. Timing of surveys varied from mid-May to the end of July. While every effort is made to conduct 5-yr surveys during the same stage of the breeding cycle, logistics, weather, funding, and time constraints dictate changes from survey to survey. Any effects from a change of mode and timing on results are identified in the regional accounts that follow.

Definitions used in the 2000 survey are consistent with those generally accepted and used in previous surveys (Murphy 1990, Holroyd and Banasch 1996). "Nest site" is the actual site of the nest on a cliff, however, the exact location of the nest may vary from year to year; "occupied site" or "occupied territory" is a location where one or two territorial adults were present; "territorial pair" is a pair that defended its nesting cliff against other peregrines or human intruders, or a pair that is persistent in remaining at the site; "breeding pair" is a pair that laid at least one egg; and "successful pair" is a pair that raised

at least one chick to fledging or that was assumed to have fledged. "Known sites" include all historically-occupied sites and any sites found occupied prior to the survey year. Sites found during the 2000 survey were "new sites." If single falcons were seen only once and no territorial behaviour was observed, or birds did not remain at a site, they were considered "sightings."

Subspecies distinctions were assigned to regional populations on the basis of historical range and were reinforced by surveyor observations of physical appearance (for an overview of peregrine subspecies distinctions see White and Boyce 1988). These distinctions are consistent with previous surveys.

Only young produced in the wild (i.e., not captive-raised) were included in determining the reproductive output of pairs. Reproductive measurements include the mean number of young fledged or assumed to have fledged/successful pair and the number of young/territorial pair (a pair that actively defends or is persistent at a nest site).

REGIONAL ACCOUNTS

Labrador, Newfoundland. *Contributed by Joe Brazil, Inland Fish and Wildlife Division, Department of Forest Resources and Agrifoods, Box 8700, St. John's, NF A1B 4J6 Canada.*

Survey area and methods. Along the Labrador coast of Newfoundland, two helicopter crews surveyed 63 historical sites. The first survey was conducted 8–12 July and covered the southern coastal nests as well as most of the interior sites. The second survey was conducted 26–31 July covering the northern coastal nests from Hopedale north as well as the rest of the interior sites.

Results and discussion. Of 63 known sites surveyed, peregrines occupied 22; single birds occupied seven; and territorial pairs occupied 15 sites. At the 15 sites, ten had young present, two had nests with eggs and two had females believed to be incubating. Ten pairs successfully produced 24 young for ratios of 2.4 young/successful pair and 1.6 young/territorial pair.

Survey area and effort was similar to that in 1995 except that more inland sites (63 versus 42) were visited in 2000. The number of occupied sites declined from 31 in 1995 to only 22 in 2000. The 1995 figure (31) was the highest number of occupied sites ever recorded in Labrador, although this was partly the result of increased search effort in the intervening period between 1990 and 1995 surveys (Brazil et al. in press). The 2000 figure (22) was similar to the number of occupied sites in 1990 (21). Declines in 2000 occurred largely in the inland sites, which were surveyed a month later than in 1995. One particular valley that had 11 of 13

sites occupied in 1999 had only two sites occupied in 2000. A single territorial bird held one of these. A cold, wet, snowy spring together with the presence of fresh white wash (excrement) at 11 sites unoccupied at the time of the survey, suggests weather and early nest failures may have been a factor in this decline. More surveys will be conducted in the near future.

Bay of Fundy (New Brunswick and Nova Scotia). *Contributed by Diane L. Amirault, Canadian Wildlife Service, Atlantic Region, P.O. Box 6227, Sackville, New Brunswick E4L 1G6 Canada, and Mark F. Elderkin, Wildlife Division, Nova Scotia Department of Natural Resources, 136 Exhibition Street, Kentville, NS B4N 4E5 Canada.*

Survey area and methods. In Nova Scotia, surveys included intensive aerial and ground checks of all known nest sites, suitable coastal habitat, and known nesting pairs. On 12–13 June, observers used a Hughes 500 helicopter to survey the Inner Bay of Fundy from Digby through Lower Blomidon and both sides of Cape Chignecto peninsula from Great Village to Joggins; the west coast of Cape Breton Island; and a series of coastal islands in St. Margaret's Bay on the Atlantic shore including Shut-In-Island, where a pair was believed to have nested successfully in 1999. Known nesting pairs were visited at least twice—early June and mid-July, to establish reproductive success.

In New Brunswick, a 1-d helicopter survey of known and potential sites was conducted on 7 July, along the Bay of Fundy coast from Saint John, northeast to the Mary's Point area, along the Petitcodiac River, and Dorchester Cape and Wood Point within Shepody Bay. Several inland sites with potential habitat were also checked with the exception of Swan Lake, which lacks suitable nesting habitat. The canyons surrounding Little Salmon River, although not previously surveyed, were covered because habitat looked suitable.

In addition to aerial surveys, young were banded in two occupied nests. A ground search late in the season was conducted in the Bayfield area, New Brunswick, because of repeated reports of Peregrine Falcon sightings throughout the season, despite the lack of suitable nesting sites. Reports from Fundy National Park wardens (Parks Canada) and local naturalists supplemented survey efforts.

Results and discussion. In Nova Scotia, five breeding pairs were located, all on cliffs within the Inner Bay of Fundy. Four pairs fledged 12 young. The

fifth pair, new in 2000, hatched at least one young that did not survive.

In New Brunswick, two known nest sites located within Shepody Bay and one known nest on Grand Manan Island were occupied. Two new territorial pairs were located during aerial surveys—both south of Fundy National Park. A minimum of seven young fledged from these five sites. A sixth pair nested in the Bayfield/Cape Jourimain area, the exact site was not found. A pair of adults was there earlier in the year and one juvenile bird was present on 8 July. One traditional nest site located in Saint John was not occupied, although two adults were present earlier. In addition to the six confirmed pairs, another site at Shepody Bay was not surveyed due to the risk of disturbing a Great Blue Heron (*Ardea herodias*) colony nearby.

The number of sites occupied in the Bay of Fundy (on both the Nova Scotia and New Brunswick sides) increased from six in 1995 to 11 in 2000 and is probably nearing historical numbers. Stocck and Pearce (1978) documented 13 historical sites in Nova Scotia and New Brunswick combined. Reproductive output in 2000 averaged 1.8 young/territorial pair and 2.0 young/successful pair.

Southern Quebec. *Contributed by Michel Lepage Société de la Faune et Des Parcs du Québec, Direction du Développement de la Faune, 675, Boul. René-Lévesque Est. 11^e étage PQ G1R 5V7 Canada.*

Survey area and methods. In 2000, surveys were limited to portions of Québec located south of 49°N. In all, 63 sites were visited including the group of rock cliffs along the Saguenay River, where three sites were occupied in 1995. No surveys were conducted in the Gaspé Peninsula because no previous information was available from there. The survey crew visited all 23 known sites where nesting previously occurred. In addition, the regional staff of the Société de la Faune et Des Parcs surveyed 28 other high-potential sites. Between two and four visits were made to each occupied site including prior to fledging of young, which enabled the survey crew to evaluate reproductive success. Surveys were conducted from ground or from boat.

Results and discussion. In 2000, Peregrine Falcons occupied 16 historical and 12 new sites; 25 sites were occupied by a pair and three by a single adult. There were 39 fledged young for 17 pairs. Reproductive output was 1.6 young/territorial pair and 2.3 young/successful pair. The majority of the 12 new sites were discovered by bird watchers and or-

nithologists as part of the Inventory Program for Threatened Bird Species in Québec.

Although the number of sites visited in 2000 (68) was less than those visited in 1995 (112), the number of occupied territories rose from 15 in 1995 to 28 in 2000 (87% increase). Pairs increased from 13–25 (92% increase). However, 12 new sites were located through the Inventory Program for Threatened Bird Species in Quebec and may reflect both different search effort and population growth. The survey confirms that most natural cliffs where Peregrine Falcons are found continue to be occupied annually. With at least six pairs, the Saguenay River area is particularly exceptional.

Most of the 28 occupied sites are on rock cliffs located along water. Only eight are on artificial structures such as skyscrapers, bridges or quarries. In at least three cases, one bird wore a red band, indicating it was released during the Canadian Peregrine Falcon release program. With no Peregrine Falcon releases in Québec since 1994 and the majority of birds in the 1995 survey without a band, we believe that some of the birds released in Ontario over the last few years have settled in Québec.

Southern Ontario. *Contributed by Brian Ratcliff and Ted Armstrong, Ontario Ministry of Natural Resources, 435 South James Street, Suite 221, Thunder Bay, ON P7E 6S8 Canada.*

Survey area and methods. Between 28 February and 11 August, surveyors and site monitors visited 40 known sites, 18 new sites, and hundreds of cliff sites in suitable habitat on foot, by boat, and helicopter (Ratcliff and Armstrong 2000). The total area surveyed extended from Thunder Bay east along Lake Superior to Sault Ste. Marie, east to North Bay, and south to Bruce Peninsula on Lake Huron. Urban centres were searched and local monitoring programs were established for known sites.

Results and discussion. There were 53 occupied sites, including 42 with territorial pairs. Attempted nesting was recorded for 31 pairs; 26 produced 68 young for 2.6 young/successful pair and 1.6 young/territorial pair. Most sites (31 or 58%) in 2000 were on cliffs located in the Lake Superior basin. In southern Ontario, urban sites dominated with nine pairs in Toronto (3), Hamilton, Ottawa, London, Mississauga, Nanticoke, and Niagara Falls. A single cliff nest in southern Ontario was located on the Bruce Peninsula, an area that peregrines reoccupied in 2000 after a 70-yr absence. The remaining 12 sites were located in both urban (6)

and rural locations (6) across the Great Lakes basin for a total of 38 cliff and 15 urban sites.

Ontario's Peregrine Falcon (*F. p. anatum*) population declined dramatically in the 1950s and 1960s with the last known nesting attempt in northern Ontario in 1963 (Armstrong in press). Captive-raised young were released between 1977 and 1996. Recovery was slow, however, with only a lone adult occupying a single territory in 1985 (Armstrong in press). In 1986, one pair and a lone bird occupied two territories (Murphy 1990). Two nesting pairs and a single territorial bird were observed during 1990 (Holroyd and Banasch 1996). Several additional occupied sites were located between 1990 and 1995 (Armstrong in press). Ontario's 2000 survey demonstrated a three-fold increase; from 15 occupied sites and 14 territorial pairs in 1995 (Ratcliff and Armstrong 2000). Although the exact proportions are unknown, this increase is partly due to increased search effort in 2000 and partly to natural population growth. An estimate of natural increase can be obtained for the west end of Lake Superior where the same effort (number of sites examined) was expended each year since 1997. There, occupancy has increased from 11 in 1997 to 23 in 2000, a natural growth rate of 109% over three years (28% annually). Similarly, the number of urban sites in southern Ontario increased from three in 1995 to 13 in 2000 (growth of 333% or 34% annually).

A total of 117 young were banded at nests adjacent to Lake Superior since 1996 and at least a portion of the current population expansion is from natural reproduction as young birds return as adults to nest. The occurrence of USA-banded birds in Ontario between 1996 and 2000, in particular five in 2000, indicates the Ontario population is at least mixing with or is a part of a larger, adjacent population. Of 33 known origin (banded) adults, five (15%) were from the U.S. (Ohio and Pennsylvania), three (9%) were from Canadian reintroduction programs and the remainder (76%) were bred and banded in the wild in Canada.

Southern Manitoba. *Contributed by Tracy Maconachie, Manitoba Peregrine Falcon Recovery Project, Box 24, 200 Saulteaux Crescent, Winnipeg, MB R3J 3W3 Canada.*

Survey area and methods. Because of the lack of records for northern Manitoba (Bechard 1981) and financial constraints, the 2000 survey effort was reduced from 1995, concentrating on known nesting, hacking, or roosting sites in and around

urban centers that were involved in the release of 170 young between 1981 and 1996 including Winnipeg, Brandon, Portage la Prairie, and Gimli (Jones et al. in press).

Results and discussion. In 2000, 21 sites with potential habitat in southern Manitoba were surveyed. Three nesting sites were occupied and monitored throughout the breeding season. These sites had two pairs (one in Winnipeg and one in Brandon) and a single bird (in Winnipeg). The two pairs hatched five young of which four successfully fledged, all from the nest in Brandon. Therefore, 4.0 young fledged/successful pair and 2.0 young fledged/territorial pair.

The 2000 data represent a decline in Manitoba peregrines from four pairs in 1995 (three sites in Winnipeg and a fourth in Brandon) (Jones et al. in press) to two in 2000. However, Manitoba peregrines are part of a larger mid-continental population (Jones et al. in press). Birds released here have been re-sighted in Saskatchewan, Alberta, and Nebraska. The first female to nest in Manitoba in 1989 was from Minnesota and a female from Iowa replaced her. Despite management, this population remains small; never exceeding four pairs, and this is unlikely to change. However, some turnover is expected in the near future as the two breeding females are 9 and 11 yr old.

Southern Saskatchewan. *Contributed by W.J. Patrick Thompson, Box 234, Clavet, SK S0K 0Y0 Canada.*

Survey area and methods. Because historical evidence for the presence of Peregrine Falcons (*F. p. anatum*) is scarce in Saskatchewan (Thompson in press) and previous surveys in potential habitat in the north discovered no nest sites, no formal survey was undertaken in Saskatchewan during 2000. However, all previously occupied urban sites were visited and, if occupied, monitored to record nesting success.

Results and discussion. In 2000, four occupied sites were located in urban areas. In Regina, a 12-yr-old female released in Winnipeg during 1988 paired with a wild 1990 male from Saskatoon. The pair fledged four young, but one young male subsequently died from a collision and a young female was turned into the Veterinary College with probable secondary carbamate poisoning. In Saskatoon, a pair produced four eggs, but abandoned them after the male disappeared midway through incubation. New, since the 1995 survey, are pairs at Moose Jaw and Prince Albert. The Moose Jaw nest site was not located (it moved from the previous

year's site), but an adult female and fledging female seen in the city in mid-July indicate a pair nested locally. In Prince Albert, a single territorial male was seen several times during the spring and summer.

In 2000, three pairs attempted breeding and two pairs fledged young. One pair successfully fledged four young. Though not located, the Moose Jaw site was believed to have fledged at least one young. To date, no occupied rural sites have been confirmed in Saskatchewan. Though anecdotal, no peregrines were seen in the South Saskatchewan River and area in 2000 (B. Hanbridge and R. Rafuse pers. comm., and P. Thompson unpubl. data). The Saskatchewan population is part of a larger mid-continental population, but, this population is unlikely to grow in the near future.

Alberta, South of 58°N. *Contributed by Rob Corrigan, Alberta Conservation Association (in partnership with Natural Resources Service, Alberta Environment), #111, 4999-98 Avenue, Edmonton, AB T6B 2X3 Canada.*

Survey area and method. Court (1993) documented peregrines as "a relatively common summer resident" in central and southern Alberta before their decline in the mid-20th century. In 2000, surveys were conducted from helicopter, boat, and on foot. Coverage was similar to the 1995 survey with 76 of 78 historical and previously known sites (Court 1993, Corrigan 2000) visited as well as suitable sites along several of Alberta's major river systems.

Results and discussion. In 2000, 23 territories were occupied by pairs. Two sites were new including the first rural site on the North Saskatchewan River since the 1960s. Nest sites were located predominately in urban areas or on man-made structures (14). There were nine rural cliff sites, which were located mostly on the Red Deer River (7). All together, 19 successful pairs produced 57 young.

Survey results (23 territories) showed an obvious significant increase in the population from 1995 (13 territories). This increase is due in part to the 223 captive-raised young released in central and southern Alberta between 1992 and 1996 (Stepnisky 1996). As well, the 80% (5–9) increase in pairs returning to rural sites indicated a recovery is underway. An average of 3.0 young/successful pair and 2.5 young/territorial pair marked an extremely good reproductive year. Of interest was: a Washington coast yearling female recovered near Drumheller, the first known occurrence of a northern Alberta banded falcon breeding in the south-

ern population (near Edmonton), and the recovery of a central Alberta bred peregrine within 100 km of the arctic coast in the Northwest Territories. As Corrigan (2000) points out, such recoveries indicate the Alberta population is not closed, and is in fact, mixing with the larger continental population.

Alberta, North of 58°, Wood Buffalo National Park and Adjacent Northwest Territories. *Contributed by Rob Corrigan, Alberta Conservation Association (in partnership with Natural Resources Service, Alberta Environment), #111, 4999-98 Avenue, Edmonton, AB T6B 2X3 Canada, Mark Bradley, Wood Buffalo National Park, Parks Canada, Fort Smith, NT, X0E 0P0 Canada, and Geoffrey Holroyd, Canadian Wildlife Service, Room 200, 4999-98 Ave. Edmonton, AB T6B 2X3 Canada.*

Survey area and methods. Peregrine Falcons (*F. p. anatum*) were first observed in Wood Buffalo National Park in 1966 (Moore et al. in press). The population low reached three pairs in 1975 and remained below ten occupied sites until 1992. From 1993–95, pairs increased from 12–23 in part due to increased search effort, which located four new sites. The area surveyed in 2000 included 27 known sites in northeastern Alberta and 21 sites within Wood Buffalo National Park (including both the Alberta and Northwest Territories portions of the park). In addition, approximately 100 cliffs were surveyed on the granite Canadian Shield east of the Slave River in northeast Alberta and the adjacent Northwest Territories. In 1995, 142 cliffs were surveyed in the same area. Most breeding sites were visited by helicopter, but sites near Fort Chipewyan were visited by boat and a few near Fort Smith were checked on foot. These survey methods were similar to 1995.

Results and discussion. In 2000, territorial pairs occupied 29 sites; only 23 attempted breeding. Of those, eight were successful, producing 21 young for a mean of 2.6 young/successful pair and 0.7 young/territorial pair.

The number of occupied territories in 2000 (29) was higher than 1995 (23). This increase was not due to additional survey effort, but represents additional pairs occupying sites and suitable cliffs that were surveyed both in 1995 and 2000.

Reproduction was extremely poor. While the majority of territorial pairs laid eggs, a number of pairs around the Fort Chipewyan area failed to fledge young. Weather may have been a factor, although sustained, cold, wet weather was not re-

corded in June at the Fort Chipewyan weather station. Reproduction per territorial pair was higher, over 1.5 young, from 1987–99 (G. Holroyd and M. Bradley unpubl. data), so we suggest that 2000 was an anomalous year.

Southwestern and Interior British Columbia (BC). *Contributed by Michael J. Chutter, British Columbia Wildlife Branch, Ministry of Environment, P.O. Box 9374, Stn. Prov. Govt., Victoria, BC V8W 9M4 Canada.*

Survey area and methods. Peregrine Falcons (*F. p. anatum*) in BC occupy the interior, lower mainland (Fraser Valley), southeast Vancouver Island, and the Gulf Islands. A helicopter survey of the lower mainland on 15 June visited eight previously known sites in the Fraser River area. Activity at two other sites was confirmed from the ground prior to the helicopter survey. All of the Vancouver Island areas, including new areas along the west and east coasts and the Gulf Islands, received more complete and expanded coverage than in previous surveys. The Gulf Islands were surveyed by boat on 15 May and 17 May and by helicopter 29–30 May. Vancouver Island was surveyed by boat 5–8 June and by helicopter on 15–16 June.

Results and discussion. During 1996, surveys in the South Okanogan located a territorial pair—the first in the area since 1959 (Chutter in press). From 1998–2000, 30 captive-raised young were released in and near Kelowna (M. Krupa pers. comm.). In 2000, incidental reports confirmed a territorial pair in the Thompson/Nicola area of the southern interior. Two other possible pairs were unconfirmed, one in the Thompson/Nicola area and one in the Williams Lake area. On the lower mainland, six sites were occupied; one site by a single territorial adult and five by territorial pairs. In the southeast Vancouver Island and Gulf Islands, 11 known sites were surveyed along the southeast coast and in the Gulf Islands, plus two new sites and several potentially suitable cliffs. Nine known and two new sites were occupied—nine with territorial pairs and two with single territorial adults. Reproductive output was not determined.

In 1995, Paul DeBruyn visited 38 known *anatum* sites in BC (Chutter in press). Of these, 21 were on cliffs near lakes, rivers, and coastal areas of the lower mainland and southwest Fraser River area including the Gulf Islands. Eleven sites were in the southern interior, four in the central interior and one each in the northwest and northeast interior areas. DeBruyn reported 19 sites occupied (17 in

the southwest, a new site in the Thompson area of the southern interior and one historical site in the northern part of the central interior). Thus, in the southern interior, lower mainland and southeast Vancouver Island and Gulf Islands, the 18 occupied sites in 2000 was comparable to 1995 results of 19 occupied sites, although areas surveyed may have differed slightly between years.

Queen Charlotte, Langara, North Vancouver, and Scott Islands, British Columbia. *Contributed by Michael J. Chutter, British Columbia Wildlife Branch, Ministry of Environment, P.O. Box 9374, Stn. Prov. Govt., Victoria, BC V8W 9M4 Canada.*

Survey area and methods. Coastal Peregrine Falcons (*F. p. pealei*) have been surveyed by the British Columbia (BC) Wildlife Branch on the Queen Charlotte Islands since the early 1960s and in the north Vancouver Island area starting in 1980 (Chutter in press). Wayne Nelson surveyed peregrines of Langara Island annually since 1968 (Nelson in press). In 1995, 87 sites were occupied in this area including 62 sites in the Queen Charlotte Islands, 7 on Langara Island, 10 on the north shore of Vancouver Island and 8 on Triangle Island. In 2000, the main survey of the Queen Charlotte Islands was conducted by boat from 18–28 May with additional surveys by boat of Langara, Reef Island, and Limestone Islands later in May and early June. The west side of Kunghit was checked in June.

Results and discussion. All combined, the 2000 survey was probably the most extensive survey of this area to date. In total, 160 of 162 known sites, six new sites, and many other suitable sites were surveyed on the above islands. As well, the north and northwest shore of Vancouver Island, the surrounding Scott Islands, other offshore islands, and parts of the adjacent mainland were surveyed including 31 known, six new, and many potential cliffs.

On the Queen Charlotte Islands, including Langara Island, 69 sites were occupied with 51 pairs defending nests. The remaining 18 sites had persistent single birds in attendance and may well have been pairs, hence the number of pairs reported here is probably an underestimate. As occupancy was the focus of the survey, reproductive data were not collected except on Langara Island, where Wayne Nelson surveyed between 31 May and 7 June. Nelson recorded nine occupied territories with two single adults and seven pairs of which five successful pairs produced nine young. For north Vancouver Island and Triangle Island, 27 of 37 sites

surveyed were occupied: 18 sites had pairs defending or an adult with a young, nine had single birds present.

The total number of territories occupied by *pealei* in BC in 2000 (96) increased over the number in 1995 (87). This increase occurred on the north part of Vancouver Island and other surrounding islands, which was surveyed more intensively in 2000 than in previous surveys. Thus, we believe the increase to be largely due to more complete survey effort. Overall, the BC *pealei* population is considered to be stable to slightly increasing.

Yukon Interior. *Contributed by Dave Mossop, Yukon College, Box 2799, Whitehorse, YT Y1A 4K4 Canada.*

Survey area and methods. Peregrine Falcons (*F. p. anatum*) breed on the cliffs of rivers draining the central Yukon. The 2000 survey was designed to monitor reproduction in the previously best-monitored core areas of each sub-population. Two sub-drainages of the Peel River were not surveyed in 2000 resulting in a smaller sample of 31 different sites in 200 compared to 40 in 1995. The scheduling of a single survey was planned to coincide with observing young approximately 20 d old. Volunteers were divided into six teams that accessed sites by boat between 27 June and 20 July. The Southern Lakes area was not surveyed in 2000 except for a visit to one unoccupied site.

Results and discussion. Of 132 sites visited in the central Yukon during 2000 on the Porcupine, Yukon, and Peel River drainages, 88 known and 15 new sites were occupied for a total of 103 territories. Of these, 55 pairs showed successful reproduction.

Although a total of 113 territories was recorded in the previous survey, based on the comparison of the same survey areas, a growth in occupancy of approximately 2.5% annually occurred since 1995 (Mossop 2000). Peregrines on the Porcupine River declined in the late 1960s, but retained a remnant population (Mossop in press). This population was the first to recover and increased up to 1990. It has remained stable over the last decade. Peregrines on the Peel River declined in the 1960s, but also retained a remnant population. They increased slowly in 1990 with significant growth in 1995 (Mossop in press). The Yukon River population declined throughout the early 1970s and with only one known occupied territory remaining, captive-raised young were fostered there from 1978–92. By 1990, this population was well above known historical levels. Over the past five years, this population

appears to have stabilized with 46 pairs identified in both the 1995 and 2000 surveys. The small number of known peregrines in the southern lakes population disappeared during the 1970s. In 1990, this population was thought to be extirpated; however, one successfully-occupied territory was located in 1995.

The production of young was very low in 2000, but at least 53% of territorial pairs produced fledglings. Clearly, monitoring on a 5-yr cycle poses some risk of hitting below average years of reproduction making the results difficult to interpret.

Yukon North Slope. *Contributed by Dave Mossop, Yukon College, Box 2799, Whitehorse, YT Y1A 4K4 Canada.*

Survey area and methods. The 2000 Yukon survey was designed to monitor reproduction in sample areas of sub-populations of which the North Slope drainage is the only Yukon area surveyed for *F. p. tundrius*. Surveys were conducted by helicopter on 11–14 July.

Results and discussion. The survey of 16 known and four new territories resulted in the location of nine occupied sites. Seven territorial pairs raised 15 young for a mean of 2.1 young/successful pair.

Peregrines (*F. p. tundrius*) on the North Slope of the Yukon were thought to be extirpated locally in 1980 (Mossop in press). Reintroductions of captive-raised young were conducted from 1983–85. In the 1990 survey, a single adult occupied a territory that had previously been occupied by a pair with three eggs in 1989 (Holroyd and Banasch 1996). Annual surveys since 1990 showed this population was in the initial stages of recovery. By 1995, there were five known nesting pairs, three produced young (Mossop in press). The number of occupied territories (9) on the Yukon's North Slope drainage increased since the 1995 survey (5 occupied territories). Within the same area surveyed during both surveys, two new nesting pairs were located and one pair disappeared in 2000 (Mossop 2000). Ivvavik National Park staff also cooperated, for the first time, in this year's effort, locating three new pairs and expanding the area now included in the survey. The North Slope population remains of concern with only seven known pairs found at the 20 territories visited.

Mackenzie Valley, Northwest Territories. *Contributed by Steve Matthews and Suzanne Carrière, Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories, Scotia Centre 5th Floor, Yellowknife, NT X1A 3S8 Canada.*

Survey area and methods. Surveys for Peregrine Falcons (*F. p. anatum*) along the Mackenzie River have occurred over the last three decades (Shank in press). The 2000 survey covered the Mackenzie Valley from Saline River, about 80 km upstream from Tulita (Fort Norman), to Inuvik, Northwest Territories (NT). The area surveyed in 2000 is the same as that surveyed in both 1990 and 1995, with some minor exceptions. Ten nest sites recorded in 1995 were not examined in 2000 due to fog, time constraints, or unknown coordinates.

We surveyed the entire study area by helicopter from 17–21 July. From 12–22 July, Keith Hodson surveyed by boat the portions of the study area directly on the Mackenzie River. All sites surveyed by boat were also surveyed by helicopter, but not vice versa.

Results and discussion. A total of 118 known sites were surveyed. As well, four new sites were found. Of the known sites, 76 (64%) were occupied in 2000. Only 37 pairs of 80 occupied sites were successful with a total of 80 young fledged from 36 sites. Mean reproduction was 1.0 young/territorial pair and 2.2 young/successful pair.

Mackenzie Valley peregrines increased dramatically through the 1980s until about 1990, when they were believed to have reached “ecological carrying capacity.” Numbers have remained fairly constant during the last decade, despite some annual fluctuations in breeding success. In 1995, 83 sites were occupied (Shank in press). In 2000, occupancy (80 sites) was slightly less than in the 1995 (83 sites) and 1990 (88 sites) surveys. However, some apparent decline may be due to the ten known sites not visited in 2000. The surveyed portions of the Mackenzie Valley may have reached a maximum occupancy for Peregrine Falcon territorial pairs in the 1990s. Similar to the 1995 survey (Shank in press), forest fires might have affected nesting occupancy and success. In 2000, we noted that some sites were lost due to fire: old raven stick nests previously used by peregrines were burned or the cliff face was modified by slumping and mud deposition.

In 2000, reproductive output, measured as the mean number of young/reproducing pair, was not significantly different from the mean of 2.3 recorded during surveys between 1969 and 1995 ($t = -0.21$, $df = 22$, $P > 0.5$). Despite habitat changes and some annual variability in reproduction during the last decade, the number of sites occupied by Peregrine Falcons during the last decade in the

Mackenzie Valley has been the highest since the survey was initiated in the mid-1960s.

Rankin Inlet, Nunavut. *Contributed by David Abernethy and Josh Hunter, Nunavut Dept. of Sustainable Development, 3rd Floor, Brown Building, P.O. Box 1340, Iqaluit, NU, X0A 0H0 Canada, and Gordon Court, Natural Resources Service, Alberta Environment, 6909-116 St. Edmonton, AB T6H 4P2 Canada.*

Survey area and methods. Peregrine Falcons (*F. p. tundrius*) have been under intensive study at Rankin Inlet, on the northwest shore of Hudson’s Bay, Nunavut, since 1980 (Court et al. 1988b). Population size and reproductive performance of all pairs within the circumscribed boundaries of the 450-km² study area were reported in national peregrine inventories in 1985, 1990, and 1995. In 2000, a single survey for territorial occupancy and reproductive output at 39 known nesting cliffs was conducted in late July.

Results and discussion. In the 2000 survey, 22 pairs of adults and three lone birds were detected at 25 sites. Sixteen successful pairs had a total of 37 young yielding 1.7 young/territorial pair and 2.3 young/successful pair.

Up to 29 pairs (annual mean 24) have occupied territories in the study area in any given year since survey boundaries and protocols were standardized in 1982. Bradley et al. (1997) summarized breeding success for the peregrine population over 13 years (1982–94) and found that in most years, 13 territorial pairs fledged young and, on average, 1.4 young (0.6–2.5 per year) were fledged/territorial pair; 2.5 were fledged/successful pair (1.8–3.1 per year). Weather conditions and prey abundance are known to have dramatic effects on the reproduction of this population (Court et al. 1988a, Bradley et al. 1997). Comparing these data to historical measures of occupancy and reproductive performance, we suggest that 2000 was an average to above-average year for the Peregrine Falcons at Rankin Inlet.

Tuktut Nogait National Park, NT. *Contributed by Joachim Obst, Box 1888, Yellowknife, NT X1A 2P4 Canada.*

Survey area and methods. In 1988 and 1990, extensive ground surveys for raptors were conducted throughout Tuktut Nogait National Park, northeast Northwest Territories. In 1991, 1996, and 1999, supplemental data were collected from visits to additional nesting sites. In total, 53 peregrine (*F. p. tundrius*) territories were identified in the park including 31 sites on the Hornaday River. In 2000,

from 17–26 July, three Parks Canada teams surveyed 160 km of the Hornaday River in the western part of Tuktut Nogait National Park by boat and on foot. Surveyors revisited 18 known sites visited previously in 1988 or 1990, as well as four new territories within the survey area. Sites were observed for 0.5–3.0 hr using a spotting scope.

Results and discussion. The 2000 survey confirmed 13 reproducing pairs, a territorial pair, and a territorial adult male in 15 of 18 known territories. Occupancy could not be ascertained at three sites due to inadequate survey time, although at two of these, fresh whitewash and/or prey remains were present indicating presence of young. In addition, four new territories with reproducing pairs were found in 2000 for a total of 19 occupied territories. Seven pairs had 18 young for a mean of 2.6 young/successful pair. Another three pairs were observed with one or more young, however, numbers of young were not confirmed. All of the remaining pairs, except for one territorial pair, were assumed to have young because they displayed vigorous defense behavior at known nest sites.

Results for 2000 indicate a stable population of Peregrine Falcons on the Hornaday River for the past decade. Although only 15 of 18 territories occupied in 1988 or 1990 were used again in 2000, four new territories in 2000 could represent a shift of pairs to alternate territories. Densities were higher in canyons and average spacing of occupied territories was 1.6 km ($N = 10$) in one section (Zoltai et al. 1992). Pairs averaged 3.1 eggs ($N = 7$) in 1988 and 3.2 eggs ($N = 5$) in 1990. During all surveys, it was not feasible to count the exact number of eggs or young in all nests but most pairs were assumed successful based on their behavior. To clarify the uncertain status of assumed “unoccupied” territories in future surveys, more time is needed for ground observations. Tuktut Nogait National Park offers the opportunity to monitor Peregrine Falcons and other raptors at a relatively low cost through ground surveys.

SYNTHESIS AND CONCLUSION

Since 1970, national surveys have been conducted every five years to locate breeding Peregrine Falcons. Survey results present the known breeding population but do not reflect the total peregrine population size. The total population would include peregrines in areas that were not surveyed, failed breeders that abandoned their sites before

surveys, non-breeding subadults and non-breeding adult floaters, which do not have territories.

Regions surveyed for *anatum* peregrines in 2000 (Table 1) were comparable to those surveyed in 1995 but effort within specific areas varied. The 2000 survey effort was less than in 1995 in Manitoba and Saskatchewan because the northern parts of neither province was searched in 2000. However, effort to identify urban pairs in the southern portion of each province was similar to 1995. Similarly, fewer cliffs east of the Slave River in northern Alberta were surveyed in 2000 than in 1995, but this did not affect numbers in the main study area which had similar survey effort in 1995 and 2000. *Anatum* surveys in the Yukon were concentrated on core areas and two drainages of the Peel River surveyed in 1995 were omitted in 2000. Similarly, 10 sites surveyed in the Mackenzie Valley in 1995 were not surveyed in 2000.

Survey effort for *anatum* was greater in 2000 in Labrador where more inland sites were surveyed. However, surveys were conducted one month later than they were in 1995. Greater effort was also expended in 2000 in the Maritimes, Ontario, and Quebec where park staff and volunteer naturalists contributed sightings that were then verified and included in survey results. As previously noted for Ontario, however, effort for annual surveys of the west end of Lake Superior has been the same since 1997. Effort was also greater in 2000 for the southern portion of Vancouver Island, BC. Effort for *anatum* in southern Alberta, interior BC and the Porcupine and Yukon Rivers, YT, was similar in 2000 to effort in 1995.

Area surveyed for *tundrius* (Table 2) was expanded from previous surveys on the Yukon's North Slope, however, a comparison was provided in the detailed regional account that compared the area covered in both 1995 and 2000. Similarly, data from Tuktut Nogait National Park, added to national results for the first time, were pulled from larger raptor surveys, but represent the findings of a comparable area searched in 1988 and 1990, and 2000. Although the area surveyed was the same at Rankin Inlet, effort was reduced with only one survey (July) conducted compared to two (May and July) in 1995 and many in 1985 and 1990. Ungava Bay *tundrius* were not surveyed in both 1995 and 2000.

Survey efforts for *pealei* (Table 2) were similar to previous years except on Vancouver Island, where the 2000 survey was the most comprehensive to

Table 1. Sites occupied by *anatum* Peregrine Falcons in Canada during 2000. ND = no data.

AREA	KNOWN SITES	KNOWN SITES CHECKED	KNOWN SITES OCCUPIED	NEW SITES	SITES OCCUPIED:	
					SINGLE BIRDS	PAIRS
Labrador, Newfoundland	63	63	22	0	7	15
Bay of Fundy (Nova Scotia, New Brunswick)	15	15	8	3	0	11
Southern Quebec	23	23	16	12	3	25
Southern Ontario	76	76	38	15	11	42
Southern Manitoba	21	21	3	0	1	2
Southern Saskatchewan	4	4	4	0	1	3
Alberta South of 58°N	78	76	21	2	0	23
Interior, British Columbia	17	1	1	0	0	1
Lower Mainland, British Columbia	10	9	5	1	1	5
Gulf Island and SE Vancouver Island, British Columbia	11	11	9	2	2	9
Alberta North of 58°N	48	48	27	2	0	29
Porcupine River, Yukon	45	36	26	9	0	35
Peel River, Yukon	48	28	19	3	0	22
Yukon River, Yukon	57	53	43	3	0	46
Southern Lakes, Yukon	1	ND	ND	ND	ND	ND
Mackenzie Valley, Northwest Territories	128	118	76	4	0	80 ^a
Total <i>anatum</i>	645	582	318	56	26	348

^a Although only a single adult with no young was observed at 26 of these sites, given the timing of surveys (mid-July), these sites are included in the number of territorial pairs.

date. Data collected in over half the regions surveyed were comparable between the 1995 and 2000 (Table 3).

Surveys attempted to cover all “historical or known sites” as well as potential sites of suitable nesting habitat. In the regions surveyed, most (ca. 90%) known sites were visited. Regions with unvisited known sites included southern Alberta (2), mainland BC (17), the interior Yukon (34), and Mackenzie Valley (10).

Although measures of reproductive success (Tables 4 and 5) and comparisons between 5-yr surveys (Tables 3 and 6) are made below, differences in survey effort, timing, and conditions must be taken into account before drawing conclusions. Where single surveys are conducted, only a minimum number of occupied territories were documented. Nesting pairs that failed prior to surveys and single adults that have less affinity to their territory may have been missed or undercounted.

Subspecies classification is not always definitive. As well, with the expansion of subspecies’ ranges, introgression may be occurring. Although considered *anatum* for this paper, the Labrador, Newfoundland population is likely on the boundary of

tundrius and *anatum*. In southwestern BC, the Fraser River and coastal mainland population is within the historical range of *anatum*. Peregrines on the Gulf Islands and along the southeast shore of Vancouver Island are also believed to be *anatum* (W. Nelson and C. White pers. comm.). And finally, known cases of *anatum* adults in southern Ontario breeding with birds of mixed race from the U.S. seaboard have occurred in recent years. To date, such subspecies classification was based on historical breeding range and physical characteristics. The identification of a genetic marker that could be used to distinguish these subspecies would be extremely worthwhile.

With these limitations in mind, it is important to realize that surveys provide a best estimate of the number of breeding peregrines within an area and do not reflect the total population size. Although comparisons of surveys conducted over 30 yr have their limitations, this large body of data provides a comparable picture of peregrine population trends in Canada.

Anatum Populations. A total of 374 sites were occupied by *anatum* in 2000 (with 93% occupied by pairs), the largest number of occupied territories

Table 2. Sites occupied by *tundrius* and *pealei* Peregrine Falcons in Canada during 2000. ND = no data.

AREA	KNOWN SITES	KNOWN SITES CHECKED	KNOWN SITES OCCUPIED	NEW SITES	SITES OCCUPIED:	
					SINGLE BIRDS	PAIRS
<i>Tundrius</i>						
Ungava Bay, Quebec	58	0	ND	ND	ND	ND
North Slope, Yukon	19	16	5	4	2	7
Rankin Inlet, Nunavut	39	39	25	0	3	22
Tuktut Nogait National Park, Northwest Territories	50	18	15 ^a	4	1	18
Total <i>Tundrius</i>	166	73	45	8	6	47
<i>Pealei</i>						
Langara Island, British Columbia	9	9	9	0	2	7
Queen Charlotte Islands, British Columbia	153	151	54	6	16	44
North Vancouver and Scott Islands, British Columbia	24	24	14	6	8	12
Triangle Island, British Columbia	10	7	7	0	1	6
Total <i>Pealei</i>	196	191	84	12	27	69

^a Two additional sites showed evidence of occupancy (fresh whitewash and/or prey remains) but were not confirmed active.

recorded to date during the 5-yr surveys. Between 1995 and 2000, the total number of occupied *anatum* territories observed increased by approximately 15% (324 to 374) (Table 3). Although this value is influenced by variation in search effort and timing, it is less than the 36% increase observed between 1990 and 1995 (Banasch and Holroyd in press). This declining rate of increase may be indicative of a recovering population that is approaching carrying capacity. Numbers for northern areas representing the largest concentration of peregrines (the Mackenzie Valley, Yukon drainages and northern Alberta) were similar to those recorded in 1995 (219–212) indicating that these regions may have stabilized and/or are approaching saturation.

In contrast, the number of occupied territories in southern Canada increased by 54% (105–162). Southern Ontario showed the largest increase, more than tripling its population (15–53) between 1995 and 2000. While some increase was due to increased search effort, at least part of the population growth is attributed to natural increase. A large number of captive-raised young *anatums* released in Ontario by hacking through to 1996 are likely responsible for at least a portion of the current breeding population. Other *anatum* populations experiencing significant growth in the num-

ber of occupied territories included the Bay of Fundy, southern Quebec, and southern Alberta, all nearly doubled in size since 1995. Labrador peregrines were the only *anatum* population to register a decline (29%) in the number of occupied territories.

The 15% increase in the number of occupied territories (occupied by a single or pair) is greater than the 9% increase in the number of territorial pairs (319 pairs in 1995 to 348 in 2000). While most *anatum* subpopulations showed increases in the number of territorial pairs, the overall total was reduced by fewer breeding pairs in Labrador and Manitoba and in smaller areas surveyed on the Peel River, Yukon. Newton (1979) described a stable population as one in which “breeding numbers remained absolutely constant or changed by less than 15% of the mean over the period concerned.” In 2000, all *anatum* subpopulations showed stable or increasing growth rates in breeding pairs over 1995, except for those in Labrador and southern Manitoba, which both declined by approximately 50% (Table 3).

Although there was some regional variation, overall *anatum* reproductive outputs remained similar to those of 1995 (Table 6) and were clearly not statistically different between the most recent surveys. Mean young/successful pair rose slightly from

Table 3 Number of sites occupied by Peregrine Falcons in selected regions of Canada from 1970 to 2000 Numbers in parentheses indicate the number of territorial pairs present. Numbers in italics indicate 2000 surveys (area and effort) were comparable to 1995. ND = no data.

AREA	1965-66	1970	1975	1980	1985-86	1990	1995	2000
<i>Anatum</i>								
Labrador, Newfoundland	0	2 (2)	0	ND	2 (2)	21 (21)	31 (31)	22 (15)
Bay of Fundy, Nova Scotia,								
New Brunswick	ND (2)	0	0	0	1 (1)	7 (5)	6 (6)	11 (11)
Southern Quebec	ND (2)	0	ND	1 (1)	1 (1)	15 (12)	15 (13)	28 (25)
Southern Ontario	0	0	0	0	1 (0)	3 (2)	15 (14)	53 (42)
Southern Manitoba	ND	ND	ND	0	1 (1)	2 (1)	4 (4)	3 (2)
Southern Saskatchewan	ND	0	ND	0	2 (1)	2 (1)	2 (2)	4 (3)
Alberta S. of 58°N	8 (6)	1 (1)	0	0	2 (2)	3 (3)	13 (12)	23 (23)
Interior British Columbia		ND	ND	ND	ND	ND	2 (2)	1 (1)
Lower Mainland, British Columbia		ND	ND	ND	ND	ND	8 (8)	6 (5)
Gulf Island & SE Vancouver Island,								
British Columbia	ND	ND	ND	5 (4) ^a	4 (2)	6 (3) ^b	9 (7)	11 (9)
Alberta N. of 58°N	ND (4)	2 (1)	3 (3)	9 (9)	6 (5)	9 (9)	23 (23)	29 (29)
Porcupine River, Yukon	ND	ND	8 (8)	16 (13)	14 (11)	36 (ND)	29 (29)	35 (35)
Peel River, Yukon	ND	ND	ND	18 (12)	12 (10)	14 (ND)	37 (37)	22 (22) ^c
Yukon River, Yukon	ND	6 (5)	6 (5)	12 (10)	22 (18)	33 (ND)	46 (46)	46 (46)
Southern Lakes, Yukon	14 (ND)						1 (1)	ND
Mackenzie Valley, Northwest Territories		9 (6)	24 (21)	20 (15)	45 (ND)	88 (77)	83 (83)	80 (80)
Total <i>anatum</i>	22 (14)	20 (15)	41 (37)	81 (64)	113 (54)	239 (134)	324 (319)	374 (348)
<i>Tundrius</i>								
Ungava Bay, Quebec	ND	12 (9)	11 (9)	10 (10)	23 (23)	34 (34)	ND	ND
North Slope, Yukon	ND	ND	5 (5)	2 (0)	0	1 (0)	5 (5)	9 (7)
Rankin Inlet, Nunavut	ND	ND	ND	8 (8) ^d	26 (ND)	26 (26)	27 (27)	25 (22)
Tuktut Nogait National Park,								
Northwest Territories						19 (19) ^e		19 (18)
Total <i>tundrius</i>	ND	12 (9)	16 (14)	20 (18)	49 (23)	80 (79)	32 (32)	53 (47)
<i>Pealei</i>								
Langara Island, British Columbia	9 (6)	6 (5)	6 (6)	6 (6)	6 (5)	7 (7)	7 (5)	9 (7)
Queen Charlotte Island,								
British Columbia	76 (55)	56 (46)	60 (51)	73 (58)	50 (ND)	64 (53)	62 (45)	60 (44)
N. Vancouver & Scott Islands,								
British Columbia	ND	ND	ND	ND	6 (5)	10 (5)	10 (6)	20 (12)
Triangle Island, British Columbia		ND	ND	ND	ND	ND	8 (8)	7 (6)
Total <i>pealei</i>	85 (61)	62 (51)	66 (57)	79 (64)	62 (10)	81 (65)	87 (64)	96 (69)

^a Gulf Island sites only.
^b Data collected in 1991.
^c A smaller section of the Peel was surveyed in 2000 compared to 1995.
^d Only a partial survey was conducted at Rankin Inlet in 1980 compared to the area surveyed in subsequent years.
^e Tuktut Nogait data were based on surveys in 1988 and 1990

Table 4. Productivity of *anatum* Peregrine Falcons in Canada during 2000. ND = no data.

AREA	TERRITORIAL PAIRS	SUCCESSFUL PAIRS	TOTAL YOUNG	MEAN YOUNG/ TERRITORIAL PAIR	MEAN YOUNG/ SUCCESSFUL PAIR
				(SAMPLE SIZE)	(SAMPLE SIZE)
Labrador, Newfoundland	15	10	24	1.6 (15)	2.4 (10)
Bay of Fundy (Nova Scotia, New Brunswick)	11	10	20	1.8 (11)	2.0 (10)
Southern Quebec	25	17	39	1.6 (25)	2.3 (17)
Southern Ontario	42	26	68	1.6 (42)	2.6 (26)
Southern Manitoba	2	1	4	2 (2)	4.0 (1)
Southern Saskatchewan	3	1	4	1.7 (3)	2.5 (1)
Alberta South of 58°N	23	19	57	2.5 (23)	3.0 (19)
Southern Interior, British Columbia	1	ND	ND	ND	ND
Lower Mainland, British Columbia	5 ^a	ND	ND	ND	ND
Gulf Islands and SE Vancouver Island, British Columbia	9 ^b	ND	ND	ND	ND
Alberta North of 58°N	29	8	21	0.7 (29)	2.6 (8)
Porcupine River, Yukon	35	21	44	1.3 (35)	2.1 (21)
Peel River, Yukon	22	12	14	0.6 (22)	1.2 (12)
Yukon River, Yukon	46	22	68	1.5 (46)	3.1 (22)
Southern Lakes, Yukon	ND	ND	ND	ND	ND
Mackenzie Valley, Northwest Territories	80	36	80	1.0 (80)	2.2 (36)
Totals/Means	348	184	444	1.5 (348)	2.5 (184)

^a Although productivity was not specifically surveyed, a minimum of seven young were detected from four sites.

^b Of three nests checked for productivity, a minimum of six chicks was observed.

2.4 in 1995 to 2.5 in 2000 with particularly good reproduction in the prairie and Yukon River populations. Mean young/territorial pair was slightly lower in 2000 (1.5 down from 1.6 in 1995). However, there was a range of highs and lows in 2000, particularly in Alberta where the southern population averaged a high of 2.5 young/territorial pair compared to 0.7 young/territorial pair in the north. Reproductive output calculated for *anatum* for the seven national surveys conducted since 1970 give an unweighted mean of 2.2 young fledged/successful pair and 1.5 young fledged/territorial pair.

The goal of the 1988 *Anatum* Peregrine Falcon Recovery Plan (Erickson et al. 1988) was “to enhance the wild *anatum* Peregrine Falcon in Canada to a level at which it was no longer considered endangered or threatened by COSEWIC.” The main objectives were “to establish by 1992 a minimum of 10 territorial *anatum* pairs in each of zones 1 to 6 . . .” and “to establish by 1997 in each of five of those six zones (zones 1–6) a minimum of 10 territorial *anatum* pairs naturally fledging 15 or more young annually, measured as a five-year average

commencing in 1993.” These goals for territory occupancy and productivity were set as interim measures only and were achieved by 1995 (Banasch and Holroyd in press). As a result, COSEWIC downlisted *anatum*s in 1999 (Johnstone 1999). Although extinction was no longer believed to be a threat, the subspecies was retained in the threatened category, due to the uncertain status of populations that were slow to expand in the south.

The 2000 survey further verified that most *anatum* populations are either stable or increasing across Canada. However, whether or not populations in the south are completely self-sustaining remains to be seen. In southern Alberta and Ontario, approximately 50% and 33% of all identified adults are still red-banded (captive-raised and released, respectively). These numbers will decline in the near future (fostering and mass hacking for the most part no longer supplement production) as mortality claims this cohort. If the remaining population is indeed self-sustaining, natural output will replace the captive-raised peregrines with those produced in the wild without any significant decline in overall population size. The national mean

Table 5. Productivity of *tundrius* and *pealei* Peregrine Falcons in Canada during 2000. ND = no data.

AREA	TERRITORIAL PAIRS	SUCCESSFUL PAIRS	TOTAL YOUNG	MEAN YOUNG/ TERRITORIAL PAIR (SAMPLE SIZE)	MEAN YOUNG/ SUCCESSFUL PAIR (SAMPLE SIZE)
<i>Tundrius</i>					
Ungava Bay, Quebec	ND	ND	ND	ND	ND
North Slope, Yukon	7	7	15	2.1 (7)	2.1 (7)
Rankin Inlet, Nunavut	22	16	37	1.7 (22)	2.3 (16)
Tuktut Nogait National Park, Northwest Territories	18	10 ^a	18	1 (18)	2.6 (10) ^b
Total/Mean	47	33	70	1.6 (47)	2.3 (33)
<i>Pealei</i>					
Langara Island, British Columbia	7	5	9	1.3 (7)	1.8 (5)
Queen Charlotte Island, British Columbia	44	ND	ND	ND	ND
Northern Vancouver and Scott Islands, British Columbia	12 ^c	ND	ND	ND	ND
Triangle Island, British Columbia	6	ND	ND	ND	ND
Total/Mean	69	5	9	1.3	1.8

^a Not included were six additional pairs which displayed extreme nest defense but were not confirmed as productive.
^b Calculated on seven pairs that produced a confirmed 18 young. The remaining three successful pairs had 1–2 or more young but numbers were not confirmed.

productivity has remained at about 1.5 young/territorial pair for the last decade.

Throughout the recovery process, there has been some concern expressed over the number of *anatum* nesting in urban settings or on man-made structures versus natural cliff sites. In 2000, of 162 known territories occupied by territorial *anatum* south of 58°N, 45 (28%) nested on buildings, bridges or industrial towers, while the rest (117 or 72%) nested on natural cliff sites. The proportion of urban sites was considerably lower than in 1990 (Holroyd and Banasch 1996).

Tundrius Populations. The number of occupied territories and the number of territorial pairs is similar in 2000 to 1995 and 1990 numbers indicating stable populations of *tundrius* at Rankin Inlet and Tuktut Nogait National Park. While a larger area was surveyed on the Yukon’s North Slope, this population is believed to be increasing slowly, although it remains relatively small. *Tundrius* reproductive outputs were 2.2 young/successful pair and 1.6 young/territorial pair, similar to 1995 values of 2.2 and 1.3, respectively.

Pealei Populations. On the West Coast, *pealei* populations of the Queen Charlotte Islands, in-

cluding Langara Island, have probably been stable since surveys began. North Vancouver Island and the surrounding area were surveyed with greater effort in 2000, however, given the large increase in numbers, is probably experiencing some population growth. Reproduction data were limited for *pealei*. However, results from Langara Island in 2000 indicated a below average year with 1.8 young/successful pair and 1.3 young/territorial pair compared to 2.0 and 1.7 in the 1995 survey.

Thus, the known peregrine population in Canada, including all three subspecies, appears to be healthy and growing. Although this species is probably approaching full recovery in the north, it can be locally affected by factors such as annual weather events, forest fires or other natural conditions that affect nesting sites and nesting conditions. In southern Canada, populations continue to recover from the low numbers of the 1970s, expanding into available urban and rural habitat. However, mass reintroductions prior to 1997 are likely to remain an influence for the next 5 yr, until the last of this supplemental cohort is replaced. Although their impact is not well understood, factors such as erratic weather events, prey availability, competi-

Table 6. Productivity of Peregrine Falcons found in selected regions of Canada surveyed every 5 yr from 1970 to 2000. Productivity data indicate mean young fledged per successful pair and in parentheses, mean young fledged per territorial pair. ND = no data.

AREA	1970	1975	1980	1985-86	1990	1995	2000
<i>anatum</i>							
Labrador, Newfoundland	2.0 (2.0)	0	ND	3.0 (1.5)	3.3 (2.6)	2.2 (1.0)	2.4 (1.6)
Bay of Fundy (Nova Scotia, New Brunswick)	0	0	0	0	2.0 (1.2)	2.4 (2.0)	2.0 (1.8)
Southern Quebec	0	ND	2.0 (2.0)	0	1.9 (1.4)	2.6 (2.0)	2.3 (1.6)
Southern Ontario	0	0	0	0	2.0 (1.3)	1.5 (1.1)	2.6 (1.6)
Southern Manitoba	ND	ND	0	0	2.0 (1.0)	3.0 (1.5)	4.0 (2.0)
Southern Saskatchewan	0	ND	0	0	1.0 (0.5)	1.5 (1.5)	2.5 (1.7)
Southern Alberta	3.0 (1.5)	0	0	2.0 (2.0)	1.5 (1.0)	3.0 (0.8)	3.0 (2.5)
Southern Interior British Columbia						ND	ND
Lower Mainland, British Columbia						ND	ND
Gulf and SE Vancouver Islands, British Columbia							ND
Northern Alberta	0	0	3.2 (2.1)	0	2.6 (1.4)	2.8 (2.2)	2.6 (0.7)
Porcupine River, Yukon	ND	ND	1.7 (1.2)	2.6 (2.0)	2.8 (1.7)	2.3 (1.3)	2.1 (1.3)
Peel River, Yukon	ND	ND	0	2.3 (1.9)	3.2 (2.4)	2.1 (0.9)	1.2 (0.6)
Yukon River, Yukon	2.0 (2.0)	1.0 (0.4)	2.2 (1.3)	2.8 (2.2)	2.4 (1.7)	2.7 (1.6)	3.1 (1.5)
Southern Lakes, Yukon						3.0 (3.0)	ND
Mackenzie Valley, Northwest Territories	2.3 (1.4)	1.3 (0.9)	2.0 (1.5)	2.1 (1.7)	2.6 (2.1)	2.6 (1.8)	2.2 (1.0)
Means	2.3 (1.7)	1.2 (0.7)	2.2 (1.6)	2.5 (1.9)	2.3 (1.5)	2.4 (1.6)	2.5 (1.5)
<i>tundrius</i>							
Ungava Bay, Quebec	1.7 (1.3)	1.8 (1.8)	2.7 (2.7)	3.2 (2.7)	3.1 (2.9)	ND	ND
North Slope, Yukon	ND	ND	0	0	0	2.3 (1.8)	2.1 (2.1)
Rankin Inlet, Nunavut	ND	ND	3.3 (2.9)	1.8 (0.6)	2.5 (0.8)	2.1 (0.7)	2.3 (1.7)
Tuktut Nogait National Park, Northwest Territories							2.6 (1.0)
Means	1.7 (1.3)	1.8 (1.8)	3.0 (2.8)	2.5 (1.7)	2.8 (1.9)	2.2 (1.3)	2.3 (1.6)
<i>pealei</i>							
Langara Island, British Columbia	2.2 (2.2)	2.4 (2.0)	2.2 (2.2)	2.0 (1.6)	2.8 (2.0)	2.0 (1.7)	1.8 (1.3)
Queen Charlotte Islands, British Columbia	2.5 (ND)	3.2 (ND)	2.5 (2.1)	ND	ND	ND	ND
Northern Vancouver Island, British Columbia	ND	ND	ND	ND	ND	ND	ND
Triangle Island, British Columbia						ND	ND
Means	2.4 (2.2)	2.8 (2.0)	2.4 (2.2)	2.0 (1.6)	2.8 (2.0)	2.0 (1.7)	1.8 (1.3)

tion from other raptors, and human disturbance may also play a role in limiting occupancy and reproduction in some areas. An effort to understand the impact of such factors will ensure this species' existence is maintained in the future.

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BREEDING SEASON HABITAT USE AND ECOLOGY OF MALE NORTHERN PYGMY-OWLS

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ABSTRACT.—We examined habitat use, nest location, diet, and activity patterns of radio-marked Northern Pygmy-Owls (*Glaucidium gnoma*) during four breeding seasons (1994–97) in fragmented forests on the Olympic Peninsula, Washington. We observed foraging in all available vegetation categories, but patterns of use were non-random. Structurally diverse and older forests were most heavily used, openings and patches of saplings received the least use, and use of edge was intermediate. We located eight nests, all in woodpecker cavities in patches of structurally-diverse forest. We found no clear evidence that nests were located near edges. Northern Pygmy-Owls were diurnally active, and male owls delivered food to females during nest establishment and incubation, and to both females and nestlings during brooding. Date of fledging varied from mid-June to mid-July. Fledging was synchronous, and minimum estimates of brood size ranged from 1–5. Diet included a mix of small birds, mammals and insects. Our results suggest that the creation of openings by clear-cut logging is unlikely to benefit Northern Pygmy-Owls, and that the replacement of structurally diverse forests with uniform forests may be detrimental.

KEY WORDS: *Northern Pygmy-Owl; Glaucidium gnoma; fragmentation; habitat use.*

ESTACION REPRODUCTIVA, USO DE HABITAT Y ECOLOGIA DEL BUHO PIGMEO MACHO DEL NORTE

RESUMEN.—Examinamos el uso de hábitat, la localización de nidos, la dieta y los patrones de la actividad de búhos pigmeos (*Glaucidium gnoma*), durante cuatro estaciones reproductoras (1994–97) en bosques fragmentados en la península Olympic, en Washington. Observamos el forrajeo en todas las categorías de vegetación disponibles, cuyos patrones de uso no estaban determinados por el azar. Los bosques más viejos y estructuralmente diversos fueron los más usados, los claros y parches de árboles fueron los mucho menos usados, la utilización de bordes fue intermedio. Localizamos ocho nidos, todos en cavidades de carpinteros en parches de bosques estructuralmente diversos. No encontramos ninguna evidencia clara que los nidos estuvieran situados cerca de los bordes. Los búhos pigmeos del norte fueron más activos durante el día, los búhos machos entregaron el alimento a las hembras durante el establecimiento de nidos y la incubación, tanto a hembras y pichones durante el empollamiento. La fecha de crecimiento de plumas en que los polluelos debían abandonar el nido varió a partir de mediados de junio hasta mediados de julio. El crecimiento de plumas fue sincrónico y las estimaciones mínimas del tamaño de la nidada fluctuaron entre 1 y 5. La dieta incluyó una mezcla de pájaros, mamíferos e insectos pequeños. Nuestros resultados sugieren que es poco probable que la creación de claros por la tala beneficie al búho pigmeo del norte y que el reemplazo de bosques estructuralmente diversos por bosques uniformes puede ser perjudicial.

[Traducción de César Márquez]

Holt et al. (1990) labeled the Northern Pygmy-Owl (*Glaucidium gnoma*) North America's least-studied owl. Thirteen years later, detailed information for this locally-common inhabitant of

western forests remains scant, and published information is often equivocal. Yet western forests have experienced decades of intense resource extraction pressure (Parry et al. 1983) and it is presently impossible to estimate how such changes might affect Northern Pygmy-Owls. Here, we report on Northern Pygmy-Owl habitat use and ecology in forests heavily fragmented by clear-cut logging.

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The range of the Northern Pygmy-Owl extends from Alaska to Central America, including forests from the west coast to the Rocky Mountains (Johnsgard 1988). They are diurnally active, use cavity nests, and are generalist predators of small birds, mammals, and insects (Bent 1938, Johnsgard 1988). Northern Pygmy-Owls have been commonly sighted in or near openings, leading to statements that they preferentially foraged in openings (Bent 1938, AOU 1983, Johnsgard 1988), nested near edges (Webb 1982, Reynolds et al. 1989), and might benefit from partial forest clearing (Johnsgard 1988). In contrast, others have suggested that partial forest clearing may be detrimental to Northern Pygmy-Owls (Marshall 1992).

Hayward and Garton (1988) used call-response surveys to examine resource partitioning by small forest owls in Idaho and concluded that the Northern Pygmy-Owl was a habitat generalist. Although their work is the most extensive study to date, many questions remain about habitat use by this species. We used radiotelemetry to study habitat use for two behaviors, foraging and nesting. We were specifically interested in whether partial forest clearing might benefit this species. We also describe home range size, diet, activity patterns, nest characteristics, and nesting behavior. For the purposes of this paper, we hereafter use 'Northern Pygmy-Owl' and 'owl' synonymously.

METHODS

The study area was a mixture of federal, state, and private lands on the northwest corner of the Olympic Peninsula, Washington. The area was hilly to mountainous with elevations ranging from 50–1350 m. Mean annual precipitation ranged from 150–250 cm. Natural vegetation was dominated by coniferous forests of western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), western red-cedar (*Thuja plicata*), and silver fir (*Abies amabilis*). Valley bottoms typically included variable amounts of bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*) (Henderson et al. 1989). Even-aged patches of primarily Douglas-fir resulted from logging and silviculture.

We located owls by walking logging roads while vocally imitating their calls. Surveys were conducted during April and May 1994–97, and were not designed to sample the study area equitably. Rather, we concentrated on areas where we had observed owls previously, and surveyed other areas less intensively. When found, owls were captured in mist nets, marked with bands issued by U.S. Geological Survey Bird Banding Laboratory; and fitted with backpack transmitters (Model BD-2G ca. 2.5 g with harness, Holohil Systems Ltd., Carp, Ontario, Canada).

Radio-marked owls were relocated several times each week during the 15-wk transmitter life span. We worked from a sequential list of radio-marked owls, locating as

many owls each day as possible (typically two to eight) and beginning where we had finished the day before. Thus, each owl was located at all times of the day, because a new owl typically topped the list each day. Location times ranged from about an hour before sunrise to about an hour after sunset.

We classified habitat into five vegetation categories based on structural characteristics. The *Open-Sapling* category included areas dominated by small conifer saplings (1–4 m tall) intermixed with extensive areas (>25% cover) of bare ground and shrub cover, mostly on recent clear-cuts. The *Early Stem Exclusion* category was dominated by young conifers (5–15 m tall) with few openings in the overstory and with dense, overlapping limbs in the understory. The *Late Stem Exclusion* category was dominated by medium-sized conifers (typically 20–40 cm DBH and >15 m tall) with a closed canopy and open understory. The *Structurally Diverse* category was characterized by a wide variety of tree sizes and a multilayered canopy. It consisted primarily of mature and older forests (typically >80 yr), but also included mid-aged stands characterized by high structural diversity. Finally, the *Edge* category included all areas within 30 m of an intersection between a patch of *Open-Sapling*, and any of the other categories. Thirty meters was used because pilot-study observations suggested that foraging flights by Northern Pygmy-Owls rarely exceeded this distance. A foraging flight was defined as any flight which included or ended with an attempt to capture prey. Because patchiness in the study area was predominantly the result of clear-cut logging, patches were generally easy to delineate and classify. We delineated patch boundaries using ARC/INFO (ESRI, Redlands, CA) and digital orthophotographs. We visited each patch and based vegetation classifications for both used and available cover on visual inspection.

We used compositional analysis (Aebischer et al. 1993) and program RESELECT (Leban 1994; available at <http://ces.iisc.ernet.in/hpg/envis/resdoc1120.html>) to compare relative use among vegetation categories. Compositional analysis treats the individual as the sampling unit, accounts for the unit-sum constraint of proportions, and allows unique availability for each individual. We used an *F*-test to determine study-wide deviation from random usage, and pairwise *t*-tests for differential use between vegetation categories.

Use ratios were calculated by dividing proportionate use by proportionate availability. Proportionate use was defined as the proportion of locations for a given owl in a given vegetation category. All locations were determined by homing to an owl with a hand-held receiver until the owl was located visually, or until triangulation indicated that the owl was directly overhead. Locations were mapped in the field on aerial photographs and subsequently digitized using digital orthophotographs. Locations of owls <50 m from an active nest were not included in the analyses because of the possibility that those locations represented nest activity rather than foraging. Removal of such locations would introduce bias if they were foraging locations. However, because all nests were located in the most heavily-used vegetation category (see below), this bias would be conservative relative to our conclusions. We assessed the error associated with

overhead triangulations by mapping the location of 12 transmitters placed in trees by an independent observer.

Proportionate availability was defined as the proportion of a given vegetation category within the minimum convex polygon (MCP) that encompassed the locations for a given owl. We used the MCP for availability because we believe it best approximated the area in which a breeding owl had the opportunity to forage. A circle centered on the nest was unsatisfactory because our pilot study revealed that nests were not always centrally located within territories, and territorial overlap was minimal. Thus, vegetation within such a circle might receive little use due to the presence of a neighboring owl. Alternatively, kernel estimators (Seaman et al. 1998) are more biased toward heavily-used vegetation patches than are MCPs, and may exclude areas that are available but used infrequently. We evaluated the sufficiency of our availability estimates with a *post hoc* analysis of MCP size in relation to the number of relocations. An inflection point was apparent at ca. 30 locations so we removed owls from further analysis if they either died or left the study area before we had accumulated 30 locations.

For comparison, we estimated home range sizes using both 100% MCP and 95% fixed kernel methods. In general, owls in this study occupied well-defined home ranges during the breeding season. However, one owl made two excursions of 6 and 11 km from its core use area for three days each in April, and then returned and nested near its original trapping location. We removed the six locations collected during these excursions from MCP home range estimation, but included them in the kernel estimates. Reynolds and Linkart (1990) discussed extra-range movements in Flammulated Owls (*Otus flammeolus*) and Linkart et al. (1998) removed extra-range movements from their home-range determinations. Programs CALHOME (Kie et al. 1996) and KERNELHR 4.28 (Seaman et al. 1998) were used for MCP and kernel analyses, respectively.

Nests were located by observing males delivering food to incubating females. The distance from each nest to the nearest edge (d_n) was measured in the field with a 50-m tape and compared to the mean distance-to-nearest-edge (\bar{d}_r) for 100 randomly generated points in the same stand. Random points and associated distances were generated with ARC/INFO. A studentized Z-statistic was calculated for each nest (Eq. 1)

$$Z = (d_n - \bar{d}_r) / s_r \quad (1)$$

where s_r is the standard deviation of the random point distances. We used a one-tailed *t*-test to test for $Z < 0$. We climbed to each nest post-fledging and measured cavity entrance and tree dimensions. Tree heights >20 m were estimated with a clinometer. We collected pellets and prey remnants from the ground near nests two to three times per wk, and recorded all observations of owls with prey. We pooled pellets and remnants for each collection date and nest, and estimated minimum vertebrate prey counts for each pooled sample. Each pellet was treated as independent for counts of insect prey. We recorded owl behaviors during three dawn-to-dusk nest watches and 34, 2-hr focal animal observations.

RESULTS

We radio-marked 21 owls during four field seasons (1994–97), including 16 males, one female, and four sex-unknowns. We had sufficient data to estimate ranges and conduct habitat use analyses for nine males (Table 1). Of those, six nested and fledged young, one nested and failed to fledge young, one nested and was thought to have failed, and the nesting status of one was undetermined. Radio-marked owls excluded from the analysis of habitat use included four males with fewer than 30 locations (Table 1), four that left the study area, two that died, one whose sex was unknown, and one female. Although we surveyed in consecutive years, we never trapped any previously banded owls.

We collected a mean of 49 locations per owl (range = 34–66, $N = 9$). Estimates of home range size (mean \pm SE) were 296 ± 42 ha ($N = 9$) for the MCP method and 209 ± 28 ha ($N = 9$) for the fixed kernel method (Table 1). Of all locations, 49% were confirmed visually and 51% were estimated by triangulation. Estimated triangulation error (mean \pm SE) for transmitters placed in trees was 11.6 ± 2.3 m ($N = 12$).

Use of vegetation categories for foraging was nonrandom ($F_{4,5} = 29.41$, $P < 0.01$). The *Structurally Diverse* category was the most used, followed by *Late Stem Exclusion*, *Edge*, *Early Stem Exclusion*, and *Open-Sapling* (Table 2). Confidence in the rank assignments for the *Open-Sapling* and *Structurally Diverse* categories was high, as indicated by low *P*-values for pairwise comparisons of rank with other vegetation categories. Confidence in the relative ranks of *Late Stem Exclusion*, *Edge*, and *Early Stem Exclusion* was low, as indicated by mostly non-significant *P*-values for pairwise comparisons. Our results suggested a dichotomy between ‘forested’ and ‘non-forested’ vegetation categories. We reanalyzed the data with the *Open-Sapling* category removed and found that the relationships between the remaining categories were qualitatively unchanged. We also analyzed the data with and without the one owl whose nesting status was not confirmed and the results were again qualitatively unchanged.

We located eight nests, all of which were in dead trees in cavities excavated by woodpeckers (Table 1). Estimated distance to the nearest edge ($\bar{x} \pm$ SE) was 59 ± 16 m for the nests and 99 ± 3 m for the random points. The studentized difference be-

Table 1. Nest characteristics and home range sizes for adult male Northern Pygmy-Owls on the Olympic Peninsula, WA, 1994–1997.

SITE-Yr	CAVITY ENTRANCE			NEST TREE		FLEDGLINGS			HOME RANGE SIZE (ha)		
	HEIGHT (m)	DIAMETER (mm)	SPECIES ^a	DBH ^b (cm)	HEIGHT (m)	MINIMUM No.	FLEDGE DATE	MCP ^c	N	FIXED KERNEL	N
LB-94	5	55	TSHE	62	8	Unknown		—	—	—	7
UB-94	16	50	TSHE	96	23	2	25 June–8 July	—	—	—	51
LB-95	6	52	TSHE	31	10	3	22 June	—	—	—	11
LC-95	5	46	TSHE	46	10	3	3 July	—	—	—	15
WC-96	6	56	TSHE	40	11	5	20 June	235	43	342	43
SK-96	Not located		—	—	—	4	14–18 June	169	40	190	40
LB-96	Not located		—	—	—	1	26–28 June	207	51	145	51
BC-96	Not located		—	—	—	Unknown		318	39	277	39
UB-97	3	57	TSHE	84	8	3	13–15 July	202	34	176	34
BC-97	8	57	ALRU	32	10	3	17 July	561	46	83	52
LB-97	Not located		—	—	—	Suspected nest failure		245	60	216	60
WC-97	Not located		—	—	—	1	10–16 July	298	64	308	64
SD-97	18	58	TSHE	54	26	Failed (eggs broken)		428	66	142	66
Mean	8.4	53.9		55.7	13.3	2.8		296	49	209	50

^a TSHE = *Tsuga heterophylla* and ALRU = *Alnus rubra*.
^b DBH = diameter at breast height.
^c MCP = minimum convex polygon.

Table 2. Use of vegetation categories by adult male Northern Pygmy-Owls on the Olympic Peninsula, Washington, 1996–97, expressed as logged use-ratio differences (SE). A positive value indicates that relative use for the row category exceeded that of column category. Categories are ranked from most (4) to least (0) used by adding the number of positive use-ratio differences across rows.

VEGETATION CATEGORY	OPEN- SAPLING	EARLY STEM EXCLUSION	EDGE	LATE STEM EXCLUSION	STRUCTURALLY DIVERSE	RANK
Open-Sapling		−2.02** (0.51)	−2.68** (0.40)	−2.74** (0.47)	−3.44** (0.33)	0
Early Stem Exclusion	2.02** (0.51)		−0.66 (0.48)	−0.72 (0.51)	−1.42* (0.49)	1
Edge	2.68** (0.40)	0.66 (0.48)		−0.06 (0.35)	−0.76** (0.17)	2
Late Stem Exclusion	2.74** (0.47)	0.72 (0.51)	0.06 (0.35)		−0.70 (0.31)	3
Structurally Diverse	3.44** (0.33)	1.42* (0.49)	0.76** (0.17)	0.70 (0.31)		4

* $P < 0.05$ from two-tailed t -tests for pairwise differences in log-ratios.
** $P \leq 0.005$ from two-tailed t -tests for pairwise differences in log-ratios.

tween nests and random points ($\bar{x} \pm \text{SE}$) was $Z = -0.51 \pm 0.31$, and did not provide sufficient evidence to show that nests were associated with edges (One-tailed $t_7 = 1.64$, $P = 0.07$). All nests were located in *Structurally Diverse* forest patches, and seven nests were in patches of late successional, (>200 yr old) coniferous forest. The eighth nest was in a relatively young, mixed patch of coniferous and deciduous trees that had regenerated naturally following logging.

Northern Pygmy-Owls consumed a variety of small birds, mammals and insects (Tables 3 and 4), and males provisioned females and nestlings during incubation and brooding. In ca. 100 hr of nest observation we saw no indication of females foraging. We observed females accepting prey items from males and retrieving cached prey items, but not leaving or returning with fresh prey items of their own. During dawn-to-dusk observations at three nests, females were either in the nest cavity or perched within 50 m, and radiotelemetry suggested that males visited the nest stand every 1–3 hr. Additionally, during the egg-laying period, fe-

males typically perched near the nest while males foraged and delivered food. We documented date of fledging for nine nests (Table 1). At four nests we observed chicks exiting the nest, and in each case, all known chicks from a given nest exited within a 6 hr period. Minimum estimates of brood size varied from one to five based on the maximum number of fledglings observed simultaneously (Table 1).

DISCUSSION

We found strong evidence that patterns of use differed from patterns of availability, indicating that owls discriminated between the vegetation categories we defined. Although use was concentrated in structurally-complex forests, we observed foraging flights in all vegetation categories. Therefore, locations in seldom-used categories cannot be attributed to owls in transit. Use of edges (as defined here) was proportionate to availability, the least used vegetation category consisted primarily of recent clear-cuts, and nests did not appear to be associated with edges. Thus, our results suggest that

Table 3. Percent composition of the diet of adult male Northern Pygmy-Owls on the Olympic Peninsula, Washington, 1996–97, based on three different methods of data collection.

METHOD	N	MAMMALS	BIRDS	INSECTS	TOTAL
Direct observation	59	45.8	50.8	3.4	100.0
Pellet analysis	83	59.0	18.1	22.9	100.0
Prey remnants	8	12.5	87.5	0.0	100.0

Table 4. Species of mammals and birds identified as prey of adult male Northern Pygmy-Owls on the Olympic Peninsula, Washington, 1996–97, based on direct observation, pellet analysis and prey remnants.

MAMMALS	BIRDS
Shrew (<i>Sorex</i> sp.)	Gray Jay (<i>Perisoreus canadensis</i>)
Coast mole (<i>Scapanus orarius</i>)	Chestnut-backed Chickadee (<i>Poecile rufescens</i>)
Deer mouse (<i>Peromyscus maniculatus</i>)	Brown Creeper (<i>Certhia americana</i>)
Red-backed vole (<i>Clethrionomys gapperi</i>)	Winter Wren (<i>Troglodytes troglodytes</i>)
Vole (<i>Microtus</i> sp.)	Golden-crowned Kinglet (<i>Regulus satrapa</i>)
Townsend's chipmunk (<i>Tamias townsendii</i>)	Thrush (<i>Catharus</i> sp.)
	Varied Thrush (<i>Ixoreus naevius</i>)
	Dark-eyed Junco (<i>Junco hyemalis</i>)
	White-crowned Sparrow (<i>Zonotrichia leucophrys</i>)
	Golden-crowned Sparrow (<i>Zonotrichia atricapilla</i>)

the creation of openings by clear-cut logging is unlikely to benefit Northern Pygmy-Owls and that the replacement of structurally diverse forests with uniform forests may be detrimental. This conclusion is subject to the caveat that habitat use may vary temporally, and we cannot exclude the possibility that different types of habitat receive heavier use in different seasons or years.

Owls in this study did not use edge habitat or openings heavily, and detection bias is one plausible explanation for this inconsistency with previous anecdotal accounts. Prior to initiating this radio-telemetry study, we observed Northern Pygmy-Owls most frequently in recent clear-cuts and along edges. Moreover, our visual confirmation rate was approximately 50% for owls in forests, compared to 100% for owls in openings. Alternatively, edges and openings created by clear-cut logging may differ in important ways from edges and openings in other contexts. For example, transitional vegetation was all but absent in our study area. Also, our definition of a 30-m buffer to define edges was arbitrary, and other definitions of edge might lead to different conclusions. Lastly, we assumed that the owls we tracked were foraging. While we attempted to strengthen this assumption by focusing on nesting males and eliminating locations near nests, we cannot demonstrate that our data reflect use for foraging. If owls used different vegetation categories for different activities, important use of some categories might be obscured by our analyses. These alternative explanations should be tested before general conclusions regarding edge associations of Northern Pygmy-Owls are drawn.

We also failed to find support for the idea that Northern Pygmy-Owls use nests near edges. How-

ever, our sample was small and the results were nearly significant ($N = 8$, $P = 0.07$). Furthermore, our approach assumed that potential nests were evenly distributed in forest patches. While it would be useful to know the true distribution of potential nests, estimating such a distribution would be problematic, and might only be relevant if potential nests were in limited supply. Our analyses were also sensitive to scale. The mean distance from a nest to the nearest edge (59 m) may be a biologically meaningful proximity that was not statistically significant in our study due to an abundance of edges. A mean distance of 99 m from random points to the nearest edge gives an indication of the ubiquitousness of edges in our study area.

Based on an analysis of forest characteristics at locations where owls responded to a vocal lure, Hayward and Garton (1988) concluded that the Northern Pygmy-Owl was a habitat generalist. At least two plausible and non-mutually exclusive hypotheses can explain the differences between their conclusions and ours. First, owls might behave differently on different study areas and second, owls might use different criteria to select habitat for home-range location, calling, and foraging. The owls we studied occupied home ranges that encompassed a diverse array of vegetation categories, but they predominantly used a subset of those categories. Additionally, calling locations and foraging locations appeared to differ (see below). Two important differences between our study and that of Hayward and Garton are that they apparently surveyed for owls at night, whereas our locations were crepuscular and diurnal, and their study included many vegetation types across a broad range of elevations.

Our results suggest the need for care when evaluating habitat associations of Northern Pygmy-Owls from opportunistic sightings or vocal lure surveys. First, of 21 owls radio-marked, 11 were initially detected responding to playbacks from forest edges (unpubl. data), yet our analyses on a subset of nine of these owls did not indicate disproportionately heavy use of edge habitat. This can most easily be explained if owls reacted to calling surveys by moving toward the perceived source before vocalizing. Proudfoot et al. (2002) documented the movement of Ferruginous Pygmy-Owls (*Glaucidium brasilianum*) toward calling stations. In our case, because surveys were conducted from logging roads, this would tend to pull owls toward edges of clear-cuts. However, we cannot exclude the possibility that edges are selected as sentinel perch areas for calling. Second, of the same 21 radio-marked owls, only 12 established territories inclusive of their original response location (unpubl. data). Lastly, we occasionally detected responses from multiple owls on the same territory at different times during a season, again suggesting that calling location and territory location may be decoupled. From our experience, the surest way to document Northern Pygmy-Owls in residence would be to repeatedly detect unsolicited vocalizations from the same area.

None of the owls that we radio-marked were re-located in subsequent years. We did monitor nesting owls in consecutive years at the same site in five cases (LB-94/95, 95/96, 96/97, WC-96/97, and BC-96/97; Table 1). Additionally, there were three sites used in one season, but vacant in the following season (UB-94, LC-95, and SK-96), for a total of eight sites where a resident male was not found at the same site in the following season. Possible explanations include: (1) nest-site fidelity was low, (2) mortality was high, (3) the study area was a population sink, and (4) radio-marking negatively affected the owls we worked with by either increasing their mortality or inducing them to find new territories. Information on the annual movements of Northern Pygmy-Owls would be useful in evaluating these hypotheses.

Seven of the eight nests we located were in late successional forests. This finding, coupled with high use in the same types of forest suggests that the loss of late-successional forest may negatively affect Northern Pygmy-Owls. However, one nest was in a mid-aged stand that differed from most of the mid-aged stands in our study area by having

greater structural diversity. This suggests that logging practices that do not result in monocultural plantations may have a lesser impact.

Our findings are similar to those of a recent study of habitat use by the Eurasian Pygmy-Owl (*Glaucidium passerinum*) (Strom and Sonerud 2001). Home range sizes for males in their study (100% MCP, 40–600 ha) overlapped our estimates and habitat use patterns were similar, except that they found that *Edge* was the highest ranked category for the Eurasian Pygmy-Owl. However, they defined *Edge* to be a 10-m-wide strip, where forest vegetation bordered open areas. To facilitate comparisons, we reanalyzed our data using their definition of *Edge*. It is important to note that although *Edge* had the highest relative rank in their study, it did not differ significantly from either of the next two highest ranked cover types (analogous to our *Structurally Diverse* and *Late Stem Exclusion* vegetation categories). In our reanalysis, the *Structurally Diverse* category again had the highest relative rank, followed by *Edge*, *Late Stem Exclusion*, *Early Stem Exclusion*, and *Open-Sapling* (results not shown). However, the relative rank of *Edge* was not significantly different than any category type except *Open-Sapling*. Thus, even though the relative rank for *Edge* increased by one, there was still insufficient evidence to conclude that Northern Pygmy-Owls used edges disproportionately.

Our natural history observations support much of the consensus knowledge regarding Northern Pygmy-Owls. We observed synchronous fledging in four instances and the dates of fledging were more similar within years than between (Table 1). The owls that we observed also exhibited a diverse diet, consistent with previous reports (Earhart and Johnson 1970, Snyder and Wiley 1976, Holt and Leroux 1996). However, we have no information on relative prey availability, and owls may exhibit prey preferences that would not be apparent in simple tallies.

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HABITAT USE BY SWAINSON'S HAWKS ON THEIR AUSTRAL WINTERING GROUNDS IN ARGENTINA

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ABSTRACT.—We examined the use of agricultural habitats by Swainson's Hawks' (*Buteo swainsoni*) in La Pampa and Santa Fe provinces, Argentina. We found an association of foraging Swainsons' Hawks with permanent pastures such as fallow, natural, and alfalfa fields. The hawks also used plowed fields for sunning, resting, and preening. Fields planted with annual crops and pastures were used very little, except when they were cut for hay, plowed, and harvested, or when low crop height and cover allowed the hawks to land in fields. The availability of abundant, yet widely-spaced and transient food-sources, such as insect outbreaks, appeared to be the principal factor influencing habitat use by the hawks. Their reliance on agricultural habitats makes Swainson's Hawks highly vulnerable to pesticide contamination and has contributed to the occurrence of significant mortality events on their wintering grounds.

KEY WORDS: *Swainson's Hawk*; *Buteo swainsoni*; *agroecosystems*; *Argentina*; *habitat use*; *wintering grounds*.

USO DE HÁBITAT DEL AGUILUCHO LANGOSTERO EN SUS ÁREAS DE INVERNADA AUSTRAL EN ARGENTINA

RESUMEN.—Estudiamos el uso de ambientes agrícolas por aguiluchos langosteros (*Buteo swainsoni*) en las provincias de La Pampa y Santa Fe, Argentina. Encontramos una fuerte asociación de los aguiluchos langosteros con pasturas perennes tal como campos enmalezados, naturales y alfalfa, que utilizaron para alimentarse en el suelo. Los aguiluchos también utilizaron campos arados para exponerse al sol, descansar y acicalarse. Los lotes de cultivos y pasturas anuales fueron usados muy poco, excepto cuando fueron cortados y enfardados, arados o cosechados, o cuando la baja altura y cobertura de las plantas les permitieron a los aguiluchos posarse en el suelo. La disponibilidad de fuentes de alimento abundantes, aunque ampliamente espaciadas y pasajeras, como las mangas de insectos, sería el factor principal que explicaría los patrones observados de uso de hábitat en estas escalas. La asociación de los aguiluchos con ambientes agrícolas hace estas aves altamente vulnerables al uso de plaguicidas, y habría contribuido a la ocurrencia de episodios de mortandad masiva en sus áreas de invernada.

[Traducción de los autores]

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Migratory birds use different habitats according to their life history requirements and seasonal environmental changes (Newton 1979, Alerstam 1990, Moore et al. 1995, Morrison et al. 1998). Their mobility and exposure to a variety of environments on breeding and wintering grounds make it especially challenging to understand their habitat use patterns (Cody 1985, Rappole 1995). In addition, their reliance on multiple habitats at different times of the year makes them particularly vulnerable to impacts from human activities (Rappole 1995), particularly agricultural activities, given the reliance that many of these birds have on crop fields and edge areas (Rodenhouse et al. 1995).

Among migratory birds, the trophic level and slow reproductive rates of raptors make them especially vulnerable to human-induced, environmental changes such as habitat fragmentation and pesticide contamination (Newton 1979, Alerstam 1990, Tella et al. 1998). Although only a small number of raptors are long-distance migrants (Alerstam 1990), most species of raptor performs some kind of migratory movement in at least part of its range. In all cases, these movements are generally associated with variations in prey availability (Newton 1979).

The Swainson's Hawk (*Buteo swainsoni*), a Neotropical migratory raptor that breeds in North America and migrates to South America for the austral summer, is typically associated with open fields such as grasslands. It has adapted to environments with a high proportion of agriculture, both in its breeding and wintering ranges (Mouchard 1996, England et al. 1997). As examples, 17.7% and 75.4% of the area within 1 km of Swainson's Hawks nests in North Dakota were cultivated crops and pasture/hayland, respectively (Gilmer and Steward 1984), and 42% of the area within foraging radius of radio-marked individuals in California was active agriculture (Woodbridge 1991). This makes the species vulnerable to impacts from agricultural practices, such as habitat modification and pesticide applications. Understanding the ecology of the Swainson's Hawk is crucial to reduce these impacts over its entire range.

Although the habitat use of the Swainson's Hawk is well documented on its breeding grounds (Bechard 1982, Schmutz 1984, 1989, Estep 1989, Woodbridge 1991, Babcock 1995, Smallwood 1995), there is little information on its habitat use on the wintering grounds (England et al. 1997, Herkert and Knopf 1998, Kirk and Hyslop 1998).

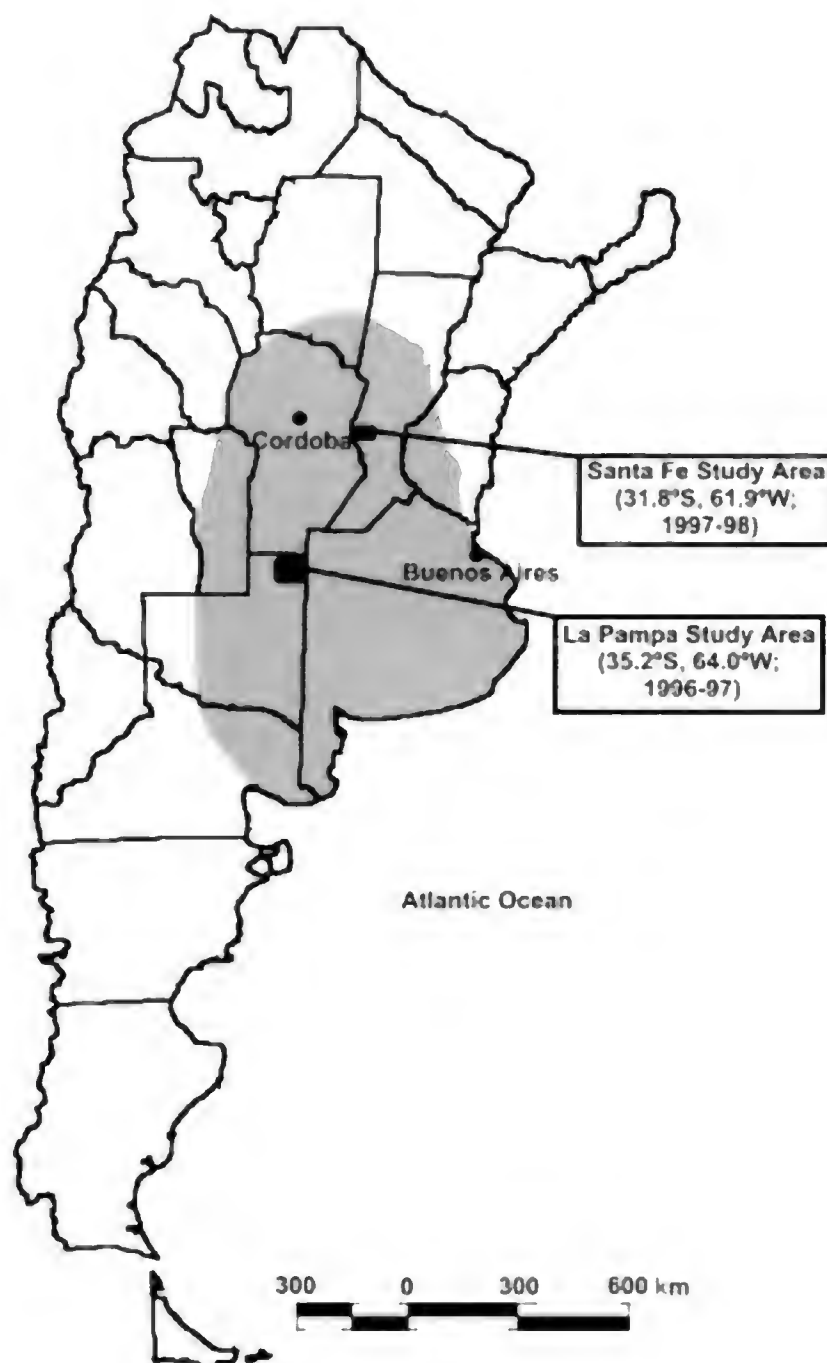


Figure 1. Approximate wintering range of Swainson's Hawks in Argentina (from CIPA 1987 and England et al. 1997) and location of the study areas.

As part of a more comprehensive project started in the austral summer of 1995–96, this study focused on the analysis of habitat use by wintering Swainson's Hawks in two areas in La Pampa and Santa Fe provinces of Argentina. Our goal was to obtain information on the ecology of wintering Swainson's Hawks in Argentina that could help to reduce the potential negative impacts of agriculture.

STUDY AREAS

Fieldwork was conducted in the northeastern portion of La Pampa and central portion of Santa Fe provinces, Argentina (Fig. 1). Between 28 November 1996 and 16 March 1997, a 2250 km² (50 × 45 km) area was established around a principal roost at "Chanilao" ranch (35.2°S, 64.0°W) in La Pampa. The area included several

locations where mass mortalities of Swainson's Hawks occurred during the previous austral summer (Woodbridge et al. 1995, Goldstein et al. 1996, Goldstein 1997). We chose this area because two study teams could cover it during one survey day, which minimized double counting of hawks for estimation of population abundances. In 1998, a 900 km² sampling area (45 × 20 km) was selected in the central portion of Santa Fe province, on the border with Córdoba province (Fig. 1). Fieldwork was carried out in this area between 7 January and 14 March 1998.

Both study areas were dominated by agricultural fields. The La Pampa area contained a mosaic of crops including sunflowers, corn, sorghum, millet, and soybeans, as well as patches of natural habitats such as *Poa* spp. and *Stipa* spp. grasslands. The Santa Fe study area was dominated (74%) by continuous cropland (mostly soybean), with the remaining of the surface (26%) dedicated to livestock and milk production over non-native pastures. La Pampa area had lower rainfall and slightly lower mean annual temperature than Santa Fe area (600–700 mm, 16°C and 800–900 mm, 17°C, respectively; Canavelli 2000).

METHODS

Individual Patterns of Daily Activity and Habitat Use. Between 16 December 1996 and 13 March 1997, focal observations of individuals were recorded to describe patterns of daily activity and habitat use within La Pampa study area. The day was divided into three equal periods: morning (0600–1040 H), midday (1041–1520 H), and afternoon (1521–2000 H) based on the length of the day during December (sunshine equal to 14 hr 35 min between 0604 and 2025 H, R. Rodriguez pers. comm.). We randomly assigned these periods to three different days each week. Locations for focal observation points were randomly selected among locations of flocks observed in the area on previous surveys (Canavelli 2000).

When a flock of hawks was found, we began a scan with binoculars starting on a randomly selected horizontal angle (at 10° intervals) and vertical section (air/ground) in which the group was previously divided, until one individual was identified. Then, we began an observation bout of 5-min conducted on that individual using 10× binoculars and a 20–60× spotting scope. A 5-min rest bout followed and then a new individual was randomly selected and observed. This procedure was repeated during the entire 280-min observation period for a total of 29 observation bouts/observation period. Observations recorded during each observation bout were: general weather conditions (cloud cover, wind speed and direction, and temperature); cover type (wheat, corn, sunflower, alfalfa, other improved pasture, native-plant pastures, fallow field, plowed field, woodland, and other); behavior of the individual hawk (soaring, active flight, and perching on the ground, fence post, light pole, and in a tree); and bird activity (preening, foraging, short runs, short flights, pecking on the ground, extension of feet while soaring, and movement of feet to the bill while soaring). Individuals were considered to be foraging on the ground if they made short runs, walks, jumps or flights usually followed by pecks to the ground to catch prey (without necessarily using talons). While soaring, hawks

were considered to be foraging when they dove, extended one or both feet to catch prey and then transferred it to the bill (Woffinden 1986).

The relative frequencies and mean frequencies of behavioral observations were analyzed using SAS System for Windows (v6.12, 1998). In order to pool all the observations for an estimation of hourly-activity budget per day, the number of observations for each behavior during each hour was scaled based on how much of the hour was completely covered on the observation periods. In this way, a balance was achieved among the unequal number of observations obtained for each hour (as result of the differences in detectability of Swainson's Hawks at different times of the day). Then, the percentage of time devoted to each activity was estimated on an hourly basis.

Habitat Selection at Population Level. Our characterization of habitat use at the population level (population is defined as the group of Swainson's Hawks sharing the study area at the same time) was based on systematic surveys conducted every 3–4 d along roadways regularly spaced over the two study areas. Twenty-two surveys were conducted in La Pampa between 21 December 1996 and 16 March 1997, and 21 were conducted in Santa Fe between 7 January and 14 March 1998. Eight surveys in La Pampa were conducted using strip transects (bandwidth of 200 and 300 m on each side, five and three surveys, respectively), while 14 surveys in this area and all the surveys in Santa Fe study area were conducted using point counts (variable circular plots; Buckland et al. 1993). In the latter case, routes were 45 km long regularly spaced every 10 km, with ten 5-min point-count stations spaced at 5 km intervals on each route, totaling 60 point-count stations in La Pampa (six routes) and 30 stations in Santa Fe (three routes; Canavelli 2000).

One or two groups of two people conducted the surveys in a vehicle driving at 40–60 km/hr during the morning (0600–1200 H) and in the afternoon (1400–2000 H). In the case of two groups (La Pampa), each group was randomly assigned to cover three routes each day, in order to reduce observer bias on different areas. Additionally, both in La Pampa and in Santa Fe, the starting point and route for the survey were randomly established, but considering each route was equivalently covered on different time periods (morning, midday, and afternoon) in order to standardize the influence of time of the day on the counts (Watson et al. 1996).

All hawks detected during each survey were recorded. Data included percent cloud cover and wind speed in qualitative categories; time of day; location using the truck odometer; and distance to the hawks from the observer estimated in intervals of 0–10, 11–50, 51–100, and 101–500 m. We also recorded land cover type, including field crops (such a corn, sunflowers, wheat, or sorghum), annual pastures (such as millet), permanent pastures (such as alfalfa), native plant pastures, fallow fields, plowed fields, and woodlands. We recorded the number of hawks (which were counted if there were individual hawks or small groups or estimated a range of numbers for large flocks); behaviors included: soaring, active flight, perched on the ground, on fence posts, on electric light posts, or in trees; bird activities: feeding in the air; feeding on the ground, preening; and resting/sunning. Two behaviors could be recorded for an individual hawk

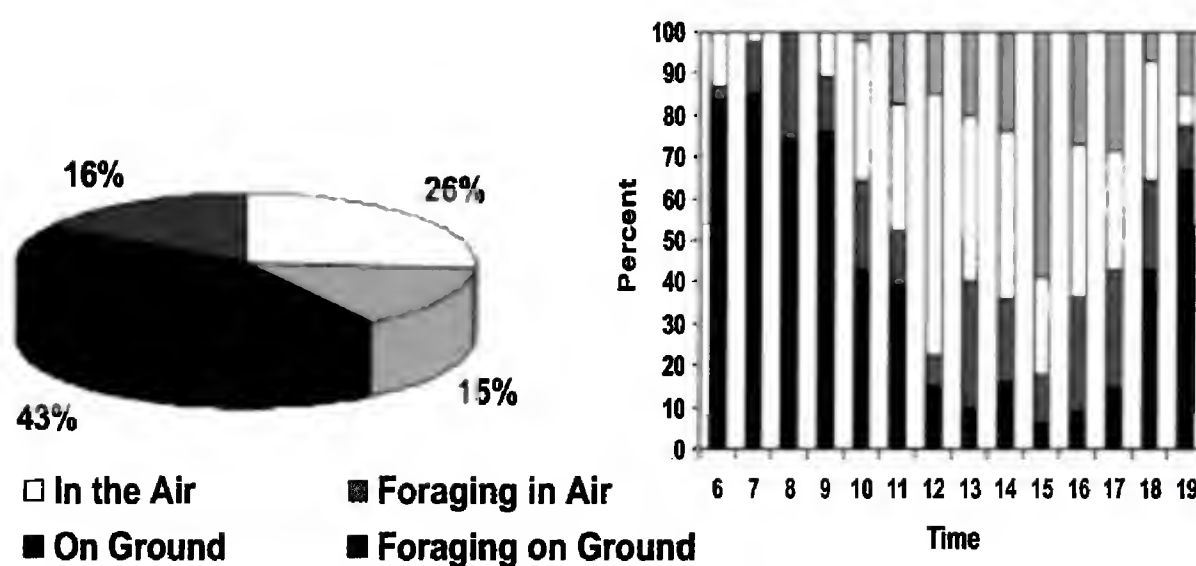


Figure 2. Daily activity pattern of Swainson's Hawks in La Pampa, Argentina ($N = 416$ observations). A. Activity budget (as percent of observations for each behavior in a day); B. Distribution of activities at different hours (as percent of observations made each hour).

(e.g., a hawk could be recorded preening and perched on a fence post).

Only counts of hawks observed on the ground were included in the habitat-use analysis because it was clear that they were using a particular cover type. We later re-assigned these counts to five cover types: cropland (sunflower, wheat, and sorghum), annual pastures (millet), permanent pastures (alfalfa and pastures >2 yr-old, natural, fallow and short-grass fields), plowed fields, and woodlands. Because the hawks usually moved in flocks (not independent individuals), habitat use was analyzed using the number of observations and not the number of hawks observed in each cover type (Thomas and Taylor 1990, Alldredge and Ratti 1992). Although we made sporadic observations of hawks using native woodlands and lowlands outside the study area in La Pampa and hawks soaring over urban areas, we made no observations of Swainson's Hawks on the ground in these areas during surveys. For this reason, these cover types were not included in the analysis of habitat use.

Habitat availability in both areas was obtained from satellite image analysis using remote sensing methodology. The National Institute of Agricultural Technology (INTA) at Castelar (Buenos Aires, Argentina) provided satellite images for both study areas (Mosaic Landsat TM, Path/Rows 228-84 and 228-85 for La Pampa and Path/Rows 228-82 and 227-82 for Santa Fe). Images included bands three (red), four (near infrared), and five (middle-infrared) and they were georeferenced to latitude and longitude. Unsupervised and supervised classifications were carried out on each area using IDRISI for Windows (v.2.008, Clark University, Eastman 1997). Eighteen land use classes were initially considered in La Pampa and 16 in Santa Fe. Later, we grouped these into six new classes: permanent pastures (alfalfa fields, native-plant pastures, short-grass fields, and fallow fields), cropland (sunflower, sorghum, corn, oat, wheat, stubble wheat, plowed fields, and annual pastures), native woodlands, *Eucalyptus* spp. woodlands, lowlands, and urban areas.

Habitat selection was estimated following Neu et al. (1974) and using the program HABUSE (Byers et al. 1984). In addition to Bonferroni's confidence intervals

estimated by this method, Bailey's intervals were estimated in order to complement those intervals obtained by the program HABUSE (Cherry 1996). Bailey's intervals are more robust for small sample sizes and provide the best combination of low error rates and interval length on the estimation of confidence intervals (Cherry 1996).

RESULTS

Individual Patterns of Daily Activity and Habitat Use. We recorded 416 activity and habitat use observations over 22 d. In the morning (0600–1040 H), we obtained 204 observations on 10 different days, 139 observations were obtained at midday (1041–1520 H) on 8 d, and 73 were obtained in the afternoon (1520–2000 H) on 7 d. Observations were made in more than one time block in the same day on only 3 d (16 December 1996, 8 and 17 January 1997).

Hawks spent most of the day (59%) sunning/resting, preening, and foraging on the ground (Fig. 2A), mainly in the morning and late afternoon (Fig. 2B). The remainder 41% of the day was spent soaring, gliding, and foraging in the air, particularly at midday. Most hawks (64–100%) stayed on the ground until 0900–1000 H, with temperatures 11–29°C (Fig. 2B). At 1100 H, hawks were observed in nearly equal proportions in the air (48%) and on the ground (52%). Between 1200–1600 H (temperatures 20–38°C), hawks were observed mostly soaring (77–82%). When the highest temperatures were registered (midday, 35–38°C), only soaring hawks were observed. At 1700 H, hawks were again observed in nearly equal proportions in the air (57%) and on the ground (43%). Finally, between 1800–2000 H (tempera-

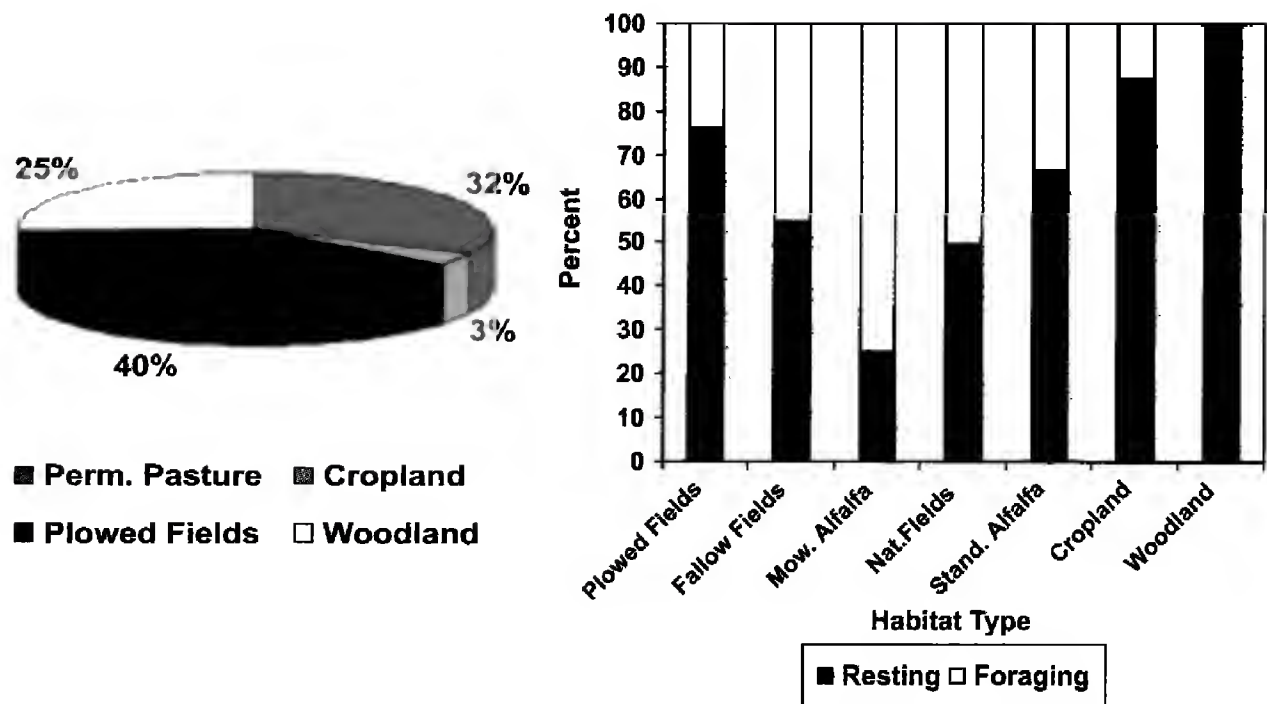


Figure 3. Cover types used by Swainson's Hawks on the ground during focal observations ($N = 279$ observations) A. Percentage of observations related to cover type; B. Percentage of observations by behavior in each cover type. Permanent pastures in A include fallow fields, mowed alfalfa, natural fields, and standing alfalfa.

tures 20–35°C), hawks were again mainly observed on the ground (67–78%, Fig. 2B).

Swainson's Hawks used various cover types for different activities at different times during the day. They mainly used plowed fields ($N = 100$ observations) and permanent pastures ($N = 84$) to sun, rest, and preen on the ground (Fig. 3A and 3B) during the day. Additionally, they used plowed fields ($N = 29$) and permanent pastures (fallow, natural, mowed, and standing alfalfa fields; $N = 38$) to forage on the ground (Fig. 3B). Plowed fields were used for foraging on the ground early in the morning ($N = 21$), while permanent pastures were used more at midday and afternoon ($N = 20$ and 10, respectively). Hawks were observed soaring and foraging in the air over several cover types ($N = 92$ and 45 observations, respectively), including permanent pastures ($N = 36$), annual crops ($N = 31$), plowed fields ($N = 28$) and annual pastures ($N = 3$), especially at midday ($N = 85$) and in the afternoon ($N = 26$). In woodlands ($N = 66$ observations), most (76%) of hawks observed were either resting or preening in trees, early in the morning or late in the afternoon ($N = 44$ and 6, respectively).

Based on our observations, a typical day for a Swainson's Hawk on its wintering grounds was divided into three periods: (1) morning, when hawks stayed mostly on the ground, in roosts, or in plowed fields located next to roosts either sunning, resting, preening, and foraging; (2) midday and

afternoon, when some hawks still remained on the ground, mostly foraging on permanent pastures, but increasingly left the ground and soared while feeding in the air over crops and pastures; and (3) late afternoon prior to roosting, when hawks are again on the ground in plowed fields and pastures preening and foraging. Hawks were usually observed using crop and pasture fields without any disturbance, but on seven sampling occasions, hawks were observed on crop and pasture fields while farm operations such as plowing, mowing or baling, and burning were conducted (four, two, and one occasions, respectively), or cattle were grazing on the fields (one occasion).

Habitat Use at the Population Level. Observations from both study areas showed that Swainson's Hawks primarily used permanent pastures which were not plowed on an annual basis (159 observations, 6265 hawks in La Pampa; 240 observations, 6885 hawks in Santa Fe; Fig. 4). In La Pampa, plowed fields followed permanent pastures in importance of use (77 observations, 3793 hawks) while in Santa Fe, annual pastures were the second most used cover type (72 observations, 1511 hawks). Cropland was more used in La Pampa than in Santa Fe, but in both study areas, observations were less than 15% of the total (36 observations, 3039 hawks and 23 observations, 141 hawks in La Pampa and Santa Fe, respectively). Less than 10% of our observations on both areas (15 observations, 329 hawks in La Pampa and 36 observations,

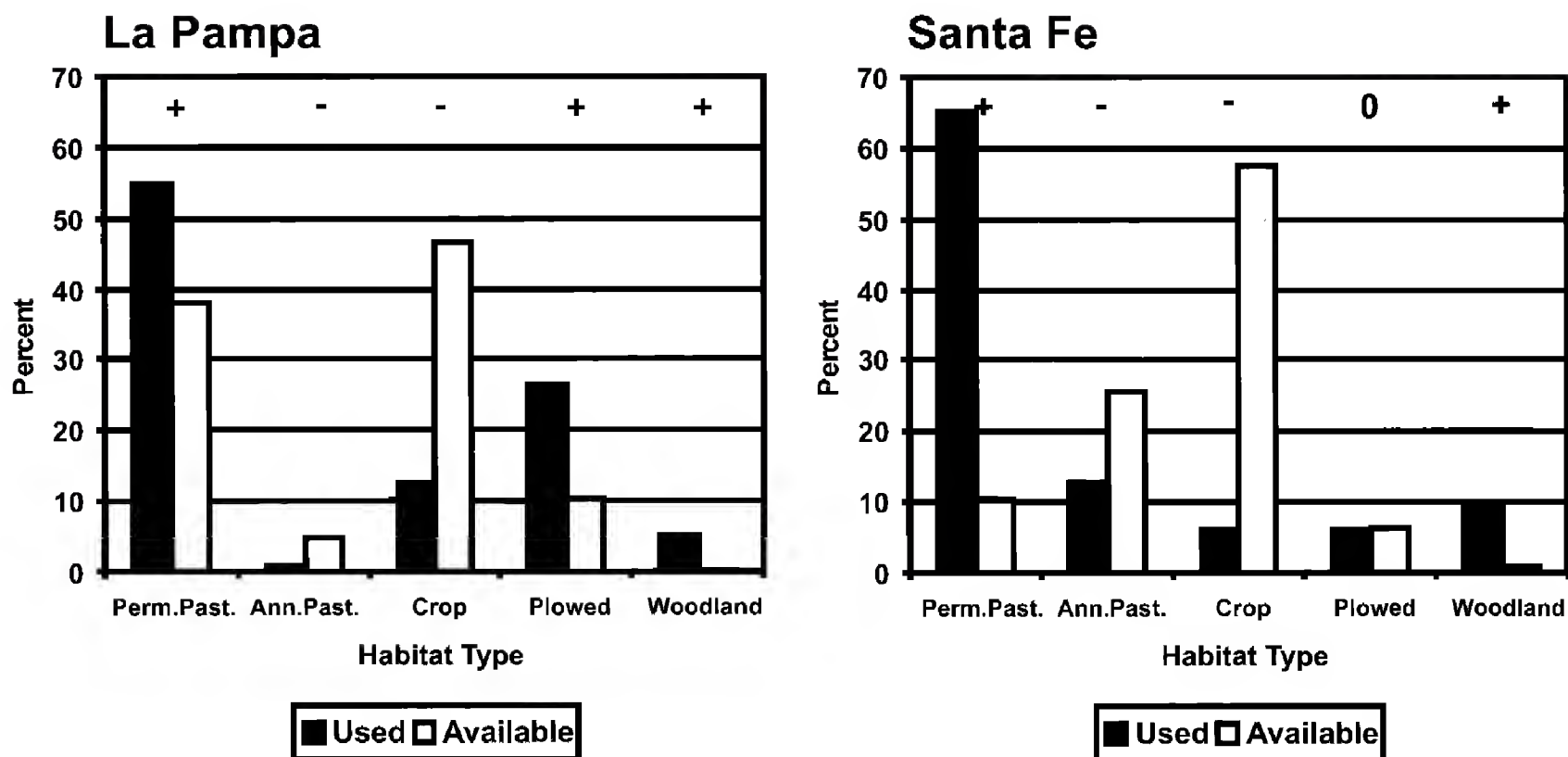


Figure 4. Habitat use vs. availability in La Pampa and Santa Fe study areas, Argentina. Habitat use is expressed as percent of observations with hawks on the ground, $N = 290$ observations in La Pampa and $N = 393$ observations in Santa Fe), and habitat availability is expressed as percent of each habitat type determined from satellite images. (+) = used more than available, (-) = used less than available, and (0) = used as available (Table 1).

844 hawks in Santa Fe) were on hawks using woodlands (Fig. 4).

Among permanent pastures, fallow, native-plant, and alfalfa fields were the most commonly used in La Pampa (70, 41, and 40 observations; 1715, 1671, and 2640 hawks, respectively). In alfalfa fields, more observations were made on standing than on mowed alfalfa (23 and 17, respectively), although fewer hawks were observed on standing alfalfa compared to mowed fields (855 and 1785 hawks, respectively). In Santa Fe, 83% (200) of observations made on permanent pastures were in fallow and short-grass fields (129 observations, 2538 hawks and 71 observations, 2456 hawks, respectively). In this case, both number of observations and hawks were greater in mowed than in standing alfalfa (23 observations, 1287 hawks and 16 observations, 603 hawks, respectively). Sixty-one percent and 77% of observations made on hawks foraging on the ground in La Pampa (14 observations, 2525 hawks) and Santa Fe (23 observations, 2069 hawks), respectively, were on permanent pastures, followed in importance by plowed fields (La Pampa: 6 observations, 1524 hawks and Santa Fe: 4 observations, 280 hawks). Fallow (26% of observations with hawks foraging on the ground in La Pampa and 27% in Santa Fe), native-plant (9% in La Pampa), short-grass (43% in Santa Fe), and al-

falfa fields (22% in La Pampa and 7% in Santa Fe) were the main permanent pastures used for foraging on the ground. Groups of hawks foraging on the ground varied between 207 (SE = 65) and 86 (SE = 37) individuals in La Pampa and Santa Fe, respectively.

In La Pampa, annual crops and pastures were mostly used when plowed than in other crop stages (65% of observations in these cover types, $N = 77$, 3793 hawks). Wheat was used when in stubble (8 observations, 1232 hawks), and corn and sunflower were used principally when emerged (cover height <40 cm; 12 observations, 1466 hawks and 15 observations, 340 hawks, respectively). In Santa Fe, 41% of 91 observations made on crops and annual pastures were on mowed millet followed by plowed and soybean fields (24% and 24%, respectively). On both areas, hawks were observed with working farm machinery, both while mowing or baling alfalfa and annual pastures (such as millet, 11 observations, 774 hawks) and plowing fields (7 observations, 333 hawks). Additionally, on six occasions (188 hawks), hawks were observed on fields being grazed by cattle.

Cropland and annual pastures comprised most of the agricultural landscape in both study areas, followed by permanent pastures (Fig. 4). Woodlands contributed little to the general land cover.

Table 1. Analysis of habitat use versus availability for La Pampa and Santa Fe study areas, Argentina. Probability of disproportional use ≤ 0.05 . (+) = used more than expected, (0) = used as expected, and (-) = used less than expected (Byers et al. 1984 and Cherry 1996).

HABITAT	OBSERVED USE (PERCENT) ^a	USE INTERVAL BYERS' INTERVALS	BAILEY'S INTERVALS	EXPECTED USE (PERCENT) ^b
La Pampa				
Permanent pasture	0.548	0.473–0.624 (+)	0.439–0.646 (+)	0.380
Annual pasture	0.010	0.000–0.026 (-)	0.000–0.047 (-)	0.049
Crops	0.124	0.074–0.174 (-)	0.063–0.201 (-)	0.465
Plowed	0.266	0.199–0.332 (+)	0.177–0.361 (+)	0.105
Woodland	0.052	0.018–0.085 (+)	0.015–0.110 (+)	0.002
Santa Fe				
Permanent pasture	0.611	0.547–0.674 (+)	0.530–0.683 (+)	0.102
Annual pasture	0.183	0.133–0.233 (-)	0.126–0.248 (-)	0.257
Crops	0.059	0.028–0.089 (-)	0.027–0.102 (-)	0.575
Plowed	0.056	0.026–0.086 (0)	0.025–0.099 (0)	0.065
Woodland	0.092	0.054–0.129 (+)	0.051–0.143 (+)	0.005

^a Percent of observations of hawks on the ground/cover type.
^b Percent values based on classified satellite image.

Swainson's Hawks used permanent pastures and plowed fields for foraging and woodlands for roosting disproportionately with respect to their availability in each study area ($\chi^2 = 531.8$, $P < 0.001$ in La Pampa; $\chi^2 = 625.6$, $P < 0.001$ in Santa Fe). Byers' and Bailey's intervals indicated that, in addition to these cover types, the hawks used plowed fields more than available in La Pampa, but in the same proportion as expected based on availability in Santa Fe (Table 1). Cropland and annual pastures were used less than expected based on their availability.

DISCUSSION

Our data indicated that Swainson's Hawks relied heavily on plowed fields and permanent pastures (Fig. 3), with the former cover type being used primarily for sunning and resting early in the morning and afternoon, and the latter one being used for foraging during midday (Fig. 2). This pattern of habitat use was probably associated with differences in physical attributes and food availability provided by each habitat type. Plowed and recently-harvested fields usually offer the best conditions for the development of thermals during the morning (R. Rodriguez pers. comm.). Swainson's Hawks spent their time sunning and resting in these fields until thermals developed in the morning and after they subsided in the afternoon. In addition, open fields may provide a greater availability of insects

(such as insect larvae) and worms early in the morning and late in the afternoon, given their movements to the upper layers to feed on vegetal matter. Coleoptera larvae and earthworms move on the soil in response to food availability, temperature, moisture and soil type (Murton 1973, Braga da Silva 1995). Finally, farm operations such as plowing and discing expose soil insects to birds, which usually forage around working farm machinery, acting as natural insect larvae control (Frana and Imwinkelried 1996). Therefore, insect larvae and worms in plowed fields and cropland would have been more abundant in the upper layers of soil when temperatures were low and moisture was high (early in the morning and late in the afternoon) or when tillage operations (such as plowing and discing) exposed them to the surface. Conversely, flying insects such as grasshoppers are more active as temperatures rise, becoming most active at midday (Liebermann and Schiuma 1946, Capinera and Sechrist 1982, Salto and Beltrame 1999), the time when we observed the hawks mainly foraging in permanent pastures.

Differences in prey availability in different habitats were also indicated by the foraging behaviors we observed while the hawks were on the ground. Swainson's Hawks are adapted to pursue mobile and exposed species such as rodents and swarms of insects, both on the ground and in the air (Eng-

land et al. 1997). The hawks we observed in plowed fields usually foraged by standing on the ground until they saw grasshoppers and other insects. Then, they used short walks, runs, and pecks to catch prey (without necessarily capturing prey with their talons first), pouncing at and running down the insects ("like domestic turkeys do," England et al. 1997). Swainson's Hawks also foraged this way in permanent pastures, but they typically made short flights and jumps in addition to short runs, apparently to flush grasshoppers.

Our observations of activity and behavior are consistent with that of a hawk with an insectivorous diet. Swainson's Hawks mainly feed on grasshoppers while wintering, although they also prey on other insects such as insect larvae, beetles, and dragonflies according to their availability (Liebermann 1935, Pereyra 1937, Liebermann 1944, White et al. 1989, Jaramillo 1993, Rudolph and Fisher 1993, Woodbridge et al. 1995, Goldstein et al. 1996, Serracin Araujo and Tiranti 1996, Goldstein 1997, Canavelli et al. 2001). Grasshoppers are usually the dominant aboveground invertebrate in pastures and natural grasslands based on biomass (Capinera et al. 1997). Additionally, agricultural practices, such as plowing, discing, mowing, harvesting, and burning of grasses and stubble are expected to increase the availability of insect prey in annual crops and pastures, as it happens with mammals, given the modification or removal of cover and prey movement generated by these operations (Bechard 1982, Tewes 1984, Caldwell 1986). In fact, both in Santa Fe and La Pampa provinces, Swainson's Hawks were observed on pasture and crop fields when operations such as mowing, baling and plowing were conducted. Therefore, the observed pattern of habitat use was as expected for an insectivorous bird preying on temporarily abundant, easily captured, and often spatially-unpredictable insect prey (Alerstam 1990, Sherry and Holmes 1995).

Food availability, as determined by prey abundance and vegetative structure, could be the key factor that determines the selection of permanent pastures as foraging sites by Swainson's Hawks during winter. On their breeding grounds, hawks usually forage on fields that offer less overall vegetative cover and greater prey availability (such as mowed or irrigated alfalfa and harvested cropland, Bechard 1982, Estep 1989, Woodbridge 1991). Observations made on different fields in Santa Fe province (Argentina) shown that fallow fields, such

as old pastures, alfalfa and short-grass fields had the highest grasshopper abundances, the lowest vegetative cover, and the greatest grasshopper availability of all the cover types used by foraging hawks (Canavelli and Salto unpubl. data).

The relationship between food availability and habitat selection by this species helps also to explain the significant mortalities of Swainson's Hawks that have been reported on the wintering grounds (Woodbridge et al. 1995, Goldstein et al. 1996). At least 5000 Swainson's Hawks were killed in pasture and crop fields by the misuse of organophosphorous pesticides (Goldstein et al. 1999), probably after they were drawn to the fields by the abundance and availability of grasshopper prey. Twelve of 19 mortality incidents occurred on alfalfa fields, with individual reports on corn, wheat, and sorghum fields (Canavelli and Zaccagnini 1996, Goldstein 1997, Goldstein et al. 1999). Although in this study, crop fields were sporadically used and not selected as foraging habitats, the combination of insect outbreaks and pesticide applications (increase on food availability of flushed prey caused by the spraying machine on the plot) could have favored the congregations of hawks on these plots, resulting in the massive mortality incidents. Additionally, applications of organophosphorous pesticides on summer crops and pastures in the region mostly occurred between December and February (Canavelli and Zaccagnini 1996), the time when Swainson's Hawks were wintering in Argentina (Woodbridge et al. 1995, England et al. 1997), and during the morning or late in the afternoon (Grue et al. 1983, R. Bogino pers. comm.), when hawks were mainly sunbathing and foraging on the ground (Fig. 2). Therefore, behavioral traits of Swainson's Hawks and the current practice of pesticide applications may synergistically increase the potential exposure of hawks to the chemicals, making these raptors particularly vulnerable to such operations.

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RAPTOR AND CHIHUAHUA RAVEN NESTING ON DECOMMISSIONED TELEPHONE-LINE POLES IN THE NORTHERN CHIHUAHUA DESERT

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ABSTRACT.—White Sands Missile Range (WSMR) in south-central New Mexico includes ca. 800 000 ha of northern Chihuahuan Desert, where little is known regarding raptor and Chihuahuan Raven (*Corvus cryptoleucus*) nesting. We studied 338 decommissioned telephone-line poles with 22 different cross-arm configurations and six electrical poles in 10 vegetation cover types from 29 March–14 September 1997. We encountered 64 Chihuahuan Raven nests on decommissioned telephone-line poles. We found 27 Swainson's Hawk (*Buteo swainsoni*) nests, most often on a configuration with two vertical poles supporting four paired sets of cross-arms. Using a geographic information system analysis, we found Chihuahuan Raven nests similarly distributed in all vegetation cover types, while honey mesquite (*Prosopis glandulosa*) desertscrub covered a mean of 64.2% of the area within 3 km of each Swainson's Hawk nest. Decommissioned telephone-line poles benefit raptors and Chihuahuan Ravens as nesting platforms, and should be managed and retained where possible in the southwest. We suggest that pole salvage operations in the northern Chihuahuan Desert should retain poles with at least two sets of paired cross-arms, which are suitable raptor and raven nesting sites. For management of Swainson's Hawks, configurations with two vertical poles supporting four paired sets of cross-arms seemed most suitable in the area we investigated.

KEY WORDS: *Swainson's Hawk*; *Buteo swainsoni*; *Chihuahuan Raven*; *Corvus cryptoleucus*; *Chihuahuan Desert*; *GIS*; *nest habitat*; *nest structure*; *poles*.

ANIDACION DE RAPACES Y DEL CUERVO DE CHIHUAHUA EN POSTES DE LINEAS TELEFÓNICAS DESCONTINUADAS EN EL NORTE DEL DESIERTO DE CHIHUAHUA

RESUMEN.—La zona de prueba de misiles de White Sand (WSMR) en el centro-sur de nuevo México incluye ca. 800,000 ha del norte del Desierto de Chihuahua, donde es poco lo que se sabe sobre la nidación de rapaces y del cuervo de Chihuahua (*Corvus cryptoleucus*). Estudiamos 338 postes de líneas telefónicas descontinuadas con 22 configuraciones con estructuras cruzadas (X) diferentes y seis postes eléctricos en 10 tipos de cobertura vegetal, desde el 29 de Marzo–14 Septiembre 1997. Encontramos 64 nidos de cuervos de Chihuahua en postes de líneas telefónicas descontinuadas. Encontramos 27 nidos de halcones de Swainsoni (*Buteo swainsoni*), la mayoría a menudo, en una configuración con dos postes verticales soportando 4 pares de sets de cruces (X). Usando análisis de sistema de información geográfica, encontramos nidos de cuervos de Chihuahua similarmente distribuidos en todos los tipos de cobertura vegetal, mientras que *Prosopis glandulosa* cubrió una media de 64.2% del área de 3 km de cada nido del gavilan de Swainsoni. Los postes de líneas telefónicas descontinuados benefician a las rapaces y a los cuervos de Chihuahua ya que sirven como plataformas de anidamiento y deberían ser manejadas y retenidas/mantenidas donde sea posible, en el suroeste. Sugerimos que operaciones de postes silvestres en el norte del Desierto de Chihuahua deberían retener/mantener postes con al menos dos sets de cruces (X) pareados, los cuales son sitios de anidación apropiados para rapaces y cuervos. Para el manejo del gavilan de Swainsoni, configuraciones con dos postes verticales soportando cuatro sets pareados de cruces (X), parecieron ser más apropiados en el área que investigamos.

[Traducción de César Márquez]

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Few investigators have examined raptor and raven nesting on artificial platforms in northern Chihuahuan Desert vegetation cover types. During a 3-yr study in southern New Mexico, Kimsey and Conley (1988) found desert, irrigated agricultural, and riparian areas with power-transmission-line support poles received more use by raptors than similar areas devoid of poles.

Other studies have described raptors nesting on natural substrates in southern New Mexico. Pilz (1983) found Swainson's Hawks (*Buteo swainsoni*) in southern New Mexico nesting in grasslands on soaptree yuccas (*Yucca elata*). England et al. (1997) described this hawk as nesting in scattered trees in grasslands, shrublands, and agricultural areas occasionally, with some nests used more than 1 yr. Bednarz and Hoffman (1988) found Swainson's Hawks nesting in large honey mesquite (*Prosopis glandulosa*) and soapberry trees (*Sapindus drummondii*) dispersed over a landscape covered by honey mesquite, shinnery oak (*Quercus havardii*), sand sage (*Artemisia filifolia*), snakeweed (*Gutierrezia sarothrae*), and creosotebush (*Larrea tridentata*) in southeastern New Mexico. Eleven nests of Chihuahuan Ravens (*Corvus cryptoleucus*) and one Swainson's Hawk nest in southeastern New Mexico were in mesquites taller than surrounding vegetation (Griffing 1974, Davis and Griffing 1977). Bednarz and Raitt (2002) described this raven as nesting in various shrubs and trees in grasslands, shrublands, and woodlands, and on human-made structures including poles.

Raptor and raven nesting ecology, on artificial and natural substrates, has been studied extensively in other regions of North America. Steenhof et al. (1993) monitored progression of use by Common Ravens (*Corvus corax*) and raptor species on newly erected power-line-transmission towers in Idaho and Oregon. In the area of these towers, nesting pairs of Common Ravens, Golden Eagles (*Aquila chrysaetos*), Red-tailed Hawks (*Buteo jamaicensis*), Ferruginous Hawks (*Buteo regalis*), and Great Horned Owls (*Bubo virginianus*) increased during the 9-yr study. In that study, nesting pairs of raptors and Common Ravens gradually abandoned nearby natural nesting substrates and began nesting on the available towers.

Bechard et al. (1990) found Red-tailed Hawk, Ferruginous Hawk, and Swainson's Hawk nesting substrates in Washington included cliffs, transmission-line towers, windmills, and trees. Red-tailed Hawks nested closest to water, primarily in the tall-

est and oldest trees, and in areas with large amounts of shrub and grassland habitat. Swainson's Hawks nested entirely in trees close to roads and human structures; nearly half of the nests were in areas where the surrounding habitat was dominated by wheat fields. This is consistent with Bednarz' (1988) investigation of breeding ecology of Swainson's Hawks in southeastern New Mexico, where grasses were a key component among the nest habitats of this species.

White Sands Missile Range (WSMR) in south-central New Mexico represents an ecologically significant portion of northern Chihuahuan Desert because of restricted access and relatively low disturbance compared to outside the WSMR boundary. The northern Chihuahuan Desert within WSMR has been devoid of agricultural activity including livestock grazing for over 50 years. Additionally, other anthropogenic developments such as buildings and associated infrastructures are limited and confined to isolated areas throughout WSMR.

WSMR contains numerous decommissioned telephone-line poles and active electrical-transmission-line poles, each consisting of a variety of configurations among several vegetation cover types. A pole configuration consists of one to several vertical poles supporting one to several paired or unpaired cross-arms. The telephone-line poles present in 1997 were retained during WSMR-wide pole removal in the early 1990s. Retained poles were those that contained a nest structure during pole removal operations and ca. 10% of other poles that had paired cross-arms, regardless of presence of a nest structure. We investigated decommissioned telephone-line poles to assess use of these structures by nesting raptors and ravens on WSMR. Using a geographic information system, we described the vegetation cover types around each decommissioned telephone-line pole.

STUDY AREA

WSMR is a military and space systems test and evaluation facility operated by the U.S. Army. Located in south-central New Mexico, WSMR encloses ca. 8000 km² of the northern Chihuahuan Desert. Topography of WSMR includes portions of the Tularosa Basin, the Jornada del Muerto, and several mountain ranges. The WSMR portion of the Tularosa Basin contains extensive gypsum dunes, lava beds, level to rolling grasslands, small marshes, and salt flats. Vegetation includes vast patches of honey mesquite, creosotebush, four-wing saltbush (*Atriplex canescens*), and grasslands of a variety of species (Dick-Peddie 1993). The Jornada del Muerto of WSMR

includes extensive patches of grasslands, honey mesquite, sand sage, and creosotebush.

Two prominent mountain ranges exist on WSMR. The San Andres Mountains dominate the west central portion of WSMR, while the Oscura Mountains dominate the northeast. High elevations of both ranges are covered with pinyon pine (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*). The rocky slopes and cliffs of both ranges are covered with mountain mahogany (*Cercocarpus montanus*) and piedmont grasslands that give way to level and rolling topography of the Tularosa Basin and Jornada del Muerto.

Weather conditions over the time of this investigation (29 March–14 September 1997) were compiled from 19 surface atmospheric monitoring stations throughout WSMR. Mean monthly precipitation throughout lowland portions of WSMR, where most decommissioned poles exist, was 3.17 cm. Maximum temperature was 44°C and minimum temperature was –6°C. Mean temperature over a 24-hr period during this investigation was 19°C. Mean wind speed throughout WSMR was 14 km/hr with peak gusts of 174 km/hr in the Jornada del Muerto and 163 km/hr in the Tularosa Basin. These were typical weather conditions on WSMR.

Developed areas of WSMR are largely limited to clusters of one to three buildings distributed throughout the range. Historically, the area that is now WSMR contained several cattle, goat, and sheep ranches. However, ranching was terminated when WSMR was officially established in 1945. Since then, grazing has been limited to feral horses and gemsbok (*Oryx gazella*), an African antelope, introduced in the late 1960s. The landscape within WSMR is minimally disturbed, as impacts of weapons and missile testing over the last 50 yr have been limited to specific areas.

METHODS

Pole Examination. All decommissioned telephone-line poles within WSMR were located using maps of the telecommunications network, or were found while conducting other investigations. Decommissioned telephone-line poles in areas of highly-restricted access (bombing, and air-to-ground gunnery ranges) on WSMR were not examined. Fewer than eight poles were known to exist in those areas.

Locations for all poles were collected with a global positioning system (GPS) receiver and differentially corrected to UTM coordinates (datum = NAD83). Poles were examined by traveling maintenance access roads that paralleled a line of poles. Pole configurations were characterized by the number of poles supporting a number of paired or unpaired cross-arms (Fig. 1). For example, a pole configuration could include two vertical poles supporting four paired or parallel cross-arms. Cross-arms were numbered from the top down on all poles.

Decommissioned telephone-line and electrical poles were examined from 5 April–2 July 1997. If a pole had an occupied raptor or raven nest, the species and date were noted and the pole was revisited during August–September 1997 to measure pole characteristics after the young had fledged.

A compass was used to collect a bearing of the long

axis of cross-arms on each pole to determine pole orientation. Pole orientation was used to determine nest exposure (placement of the nest on cross-arms relative to exposure to wind and solar radiation). This measurement was taken to investigate whether raptors or ravens nested on a specific side of a vertical pole relative to the pole's orientation. The bearing was taken in the direction the nest received the most exposure.

Heights of pole features were measured with a telescoping fiberglass rule to the nearest centimeter. Cross-arm heights, distances between cross-arms, distances between the top of the nest and underside of the above cross-arm, and pole heights were measured only on those decommissioned telephone poles with occupied and unoccupied nests. Herein, decommissioned telephone-line pole configurations are identified using the number of vertical poles and the number of paired cross-arms. For example, a single vertical pole supporting four sets of cross-arms is denoted as a 1X4.

Vegetation Characterization. Vegetation cover types within a 3-km radius of each pole were identified using a GIS. These cover types included arid grasslands dominated by blue (*Bouteloua gracilis*), hairy (*B. hirsuta*), and black (*B. eriopoda*) grama, mesa dropseed (*Sporobolus flexuosus*), giant sacaton (*Sporobolus wrightii*), and tobosa (*Pleuraphis mutica*); shrublands dominated by four-wing saltbush, creosotebush, honey mesquite, and mountain mahogany; and woodlands dominated by pinyon and juniper (Dick-Peddie 1993, Muldavin et al. 1996).

From the GPS location of each pole, a polygon with a 3-km radius was placed around each point location. The polygon equated to a vegetation sampling area of 28.1 km², or 2810 ha in the GIS (ArcInfo, Environmental Systems Research Institute, Redlands, CA). This vegetation assessment area was chosen to permit inclusion of home range sizes for raptors known to nest in the area. Tabulation of vegetation cover types with a GIS was conducted using a digital version of the New Mexico Gap Analysis Project (NM-GAP) vegetation data set (Muldavin et al. 1996, Thompson et al. 1996). This digital data set provided vegetation classes mapped at 100-ha resolution with an accuracy of 77% at the most general classification (Thompson et al. 1996).

RESULTS

Pole Examination. We examined 338 decommissioned telephone-line poles of 22 different configurations on WSMR. Of the 22 configurations, four comprised 86.3% of the available decommissioned poles (Fig. 1a, b, c, d). Three configurations, consisting of 12 poles, were considered incapable of supporting raptor or raven nests because of unpaired cross-arms and overall poor condition (e.g., Fig. 1e). We located 23 box-style decommissioned telephone-line poles comprising 10 configurations on WSMR (Fig. 1f).

Orientations of decommissioned telephone-line poles were not evenly distributed, with 67.4% of 311 poles oriented east/west or northwest-southeast (Table 1). Box-style configurations were not

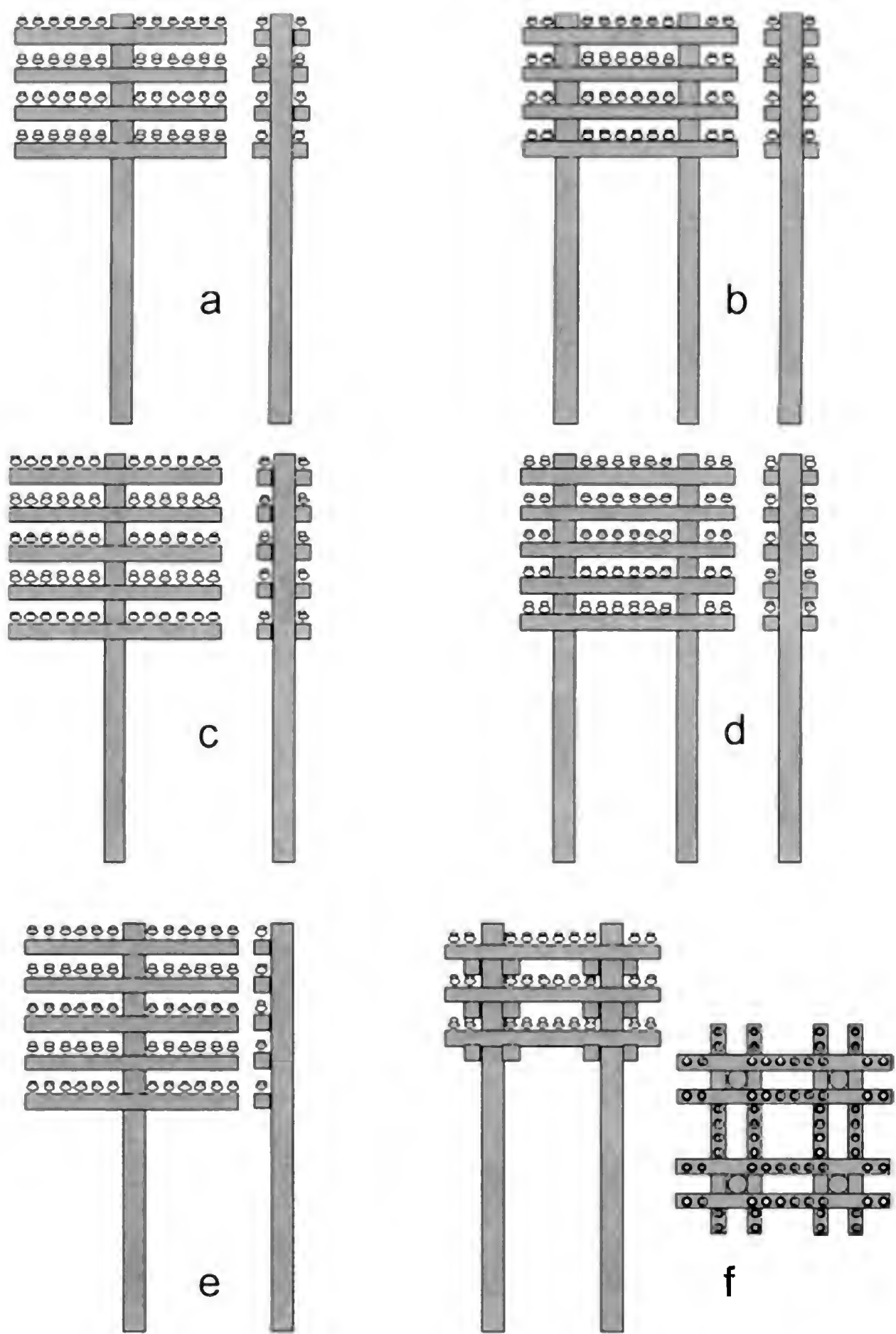


Figure 1. Examples of decommissioned telephone-line pole configurations found in the northern Chihuahuan Desert on White Sands Missile Range, New Mexico, 1997.

used in orientation and exposure analyses because these configurations were oriented in multiple directions. Dimensions of decommissioned telephone-line pole features such as distance between cross-arms, length of cross-arms, and distance between vertical poles were consistent among pole

configurations. Cross-arms were 3 m long and vertically spaced 50 cm apart. Vertical poles were spaced 2 m apart in two- and four-pole configurations. Decommissioned telephone poles were 7.94–10.55 m tall with heights of cross-arms varying accordingly. No pole configuration was consistently

Table 1. Orientation of decommissioned telephone-line poles used as nesting substrates by the two most common pole-nesting species in the Chihuahuan Desert on White Sands Missile Range, New Mexico, 1997.

	ORIENTATION			
	EAST-WEST	NORTH-EAST-SOUTH-WEST	NORTH-SOUTH	NORTH-WEST-SOUTH-EAST
All poles (<i>N</i> = 311)	114 ^a (36.6) ^b	65 (20.9)	36 (11.6)	96 (30.8)
Chihuahuan Ravens (<i>N</i> = 61)	21 (34.4)	11 (18.1)	7 (11.5)	22 (36.1)
Swainson's Hawks (<i>N</i> = 26)	12 (46.2)	4 (15.4)	4 (15.4)	6 (23.1)

^a Number of poles having a specific orientation.
^b Percentage of occurrence.

taller than others. Within a line of decommissioned telephone-line poles, distances between poles ranged from 4.6–1200 m.

Raptor and Raven Nests. We detected 64 Chihuahuan Raven, 27 Swainson's Hawk, three Red-tailed Hawk, and two Great Horned Owl nests among the decommissioned telephone-line poles (Fig. 2). Four Red-tailed Hawk and two Chihuahuan Raven nests were detected on electrical poles (Fig. 2). Nests on telephone-line poles were concentrated in the Tularosa Basin, while nests on electrical poles were encountered mostly on the Jornada del Muerto (Fig. 2). Subsequent analyses and discussion focus only on Chihuahuan Raven and Swainson's Hawk nests on decommissioned telephone-line pole nests.

Chihuahuan Raven Nests. Of 19 telephone-line pole configurations available as nesting platforms, Chihuahuan Ravens nested on five (Table 2). Additionally, for configurations with more than one vertical pole, raven nests were most often between vertical poles (Table 3). Also, 37.1% of raven nests were on cross-arm number two, while cross-arm number four supported 33.9% of the nests (Table 2). Mean heights of cross-arms two and four were 7.88 m (SD = 0.42) and 7.01 m (SD = 0.67), respectively.

Analysis of exposure potential for 61 Chihuahuan Raven nests (data missing for three nests) indicated orientation away from direction of pre-

vailing wind and afternoon solar radiation. We found that 26.2%, 19.7%, and 16.4% of these nests were exposed to the east, southeast, and northwest, respectively (Table 4).

Chihuahuan Raven nests on telephone poles displayed a similar distribution among vegetation cover types and pole configurations as was present on WSMR (Table 5). Within 3 km of Chihuahuan Raven nests, honey mesquite desert scrub covered a mean of 13.3 km² or 48.3% of each of the 28.1 km² polygons around 64 poles containing Chihuahuan Raven nests (Table 5). Black grama/dropseed grassland and creosotebush desert scrub covered most of the remaining area (Table 5).

Analysis of vegetation cover types within 3 km of the four pole configurations most used by nesting Chihuahuan Ravens indicated some differences in composition between the four-cross-arm configurations and the five-cross-arm configurations. Area around 1X4 and 2X4 configurations used by Chihuahuan Ravens had fewer vegetation cover types than the 1X5 and 2X5 configurations used by this species (Fig. 3). Four-wing saltbush and black grama/dropseed grassland covered the greatest area within the 3-km radius polygons around Chihuahuan Raven nests on 1X5s compared to available 1X5s. Chihuahuan Raven nests on 2X5s had more honey mesquite desert scrub covering the area around these poles relative to all 2X5s.

Swainson's Hawk Nests. Swainson's Hawks nested on five configurations of decommissioned telephone-line poles (Table 6). Nearly half of the nests (48.2%) were on the 2X4 configuration; however, this configuration comprised 19.2% of all decommissioned poles (Table 6). Exposure potential for 26 Swainson's Hawk nests (data missing for one nest) revealed that 34.6% were exposed to the east and 23.1% were exposed to the northwest (Table 4). All Swainson's Hawk nests on telephone poles were in the Tularosa Basin (Fig. 2).

Most (66.6%) of Swainson's Hawk nests were on cross-arm two (Table 6). Mean height of cross-arm two on the 1X4 configuration was 7.54 m (SD = 0.55) and 8.27 m (SD = 0.70) for the 2X4 configuration. Swainson's Hawk nests were placed most often between vertical poles on configurations with more than one vertical pole (Table 3).

Honey mesquite desert scrub covered a mean of 18.1 km² or 62.8% of the area in each 28.1 km² polygon around poles with Swainson's Hawk nests (Table 5). Black grama/dropseed grassland con-

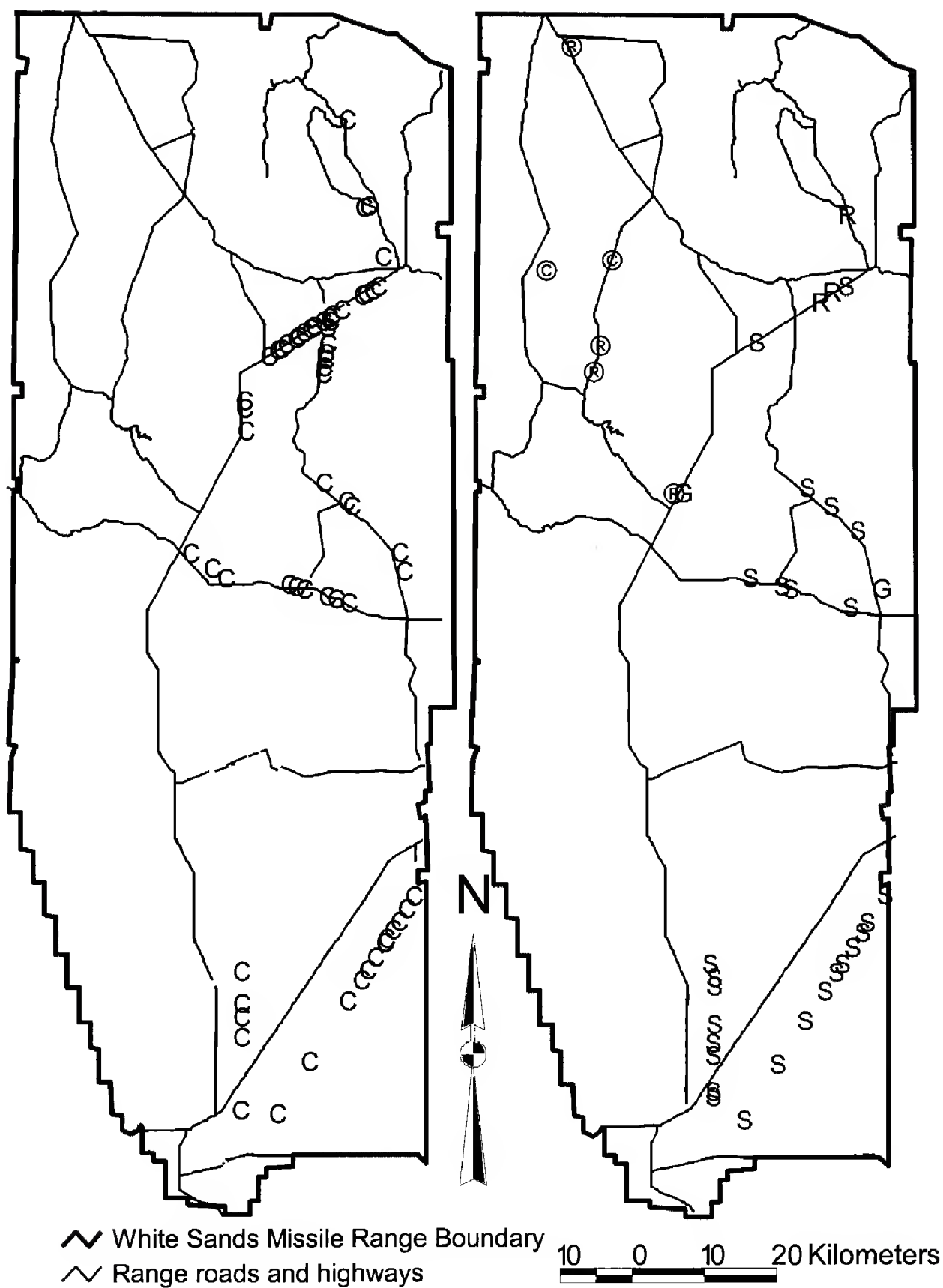


Figure 2. Distribution of Chihuahuan Raven (C), Swainson's Hawk (S), Red-tailed Hawk (R), and Great Horned Owl (G) nests on decommissioned telephone-line poles, and nests of Red-tailed Hawks ® and Chihuahuan Ravens © on active electrical transmission line poles in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.

tributed 17.6% of the remaining area, or a mean of 4.8 km² of polygon area (Table 5). Analysis of vegetation cover types within 3 km of the two-pole configurations most used by nesting Swainson's Hawks indicated that land-cover around the 2X4 configuration was composed mostly of honey mesquite desert scrub (Fig. 4). Additionally,

land-cover within 3 km of the 1X4 configuration was more diverse than that of the 2X4 configuration (Fig. 4). DISCUSSION Greater use of 2X4 cross-arm configurations by Swainson's Hawks and 2X5 configurations by Chi-

Table 2. Placement of 62 Chihuahuan Raven nests among cross-arms on five decommissioned telephone-line pole configurations in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.^a

CROSS-ARM No. ^b	POLE CONFIGURATIONS ^c					No. (PERCENT)
	1X4	2X4	1X5	2X5	4X22	
1	0	0	0	0	0	0
2	8	4	1	10	0	23 (37.1)
3	4	3	0	3	1	11 (17.7)
4	6	6	6	3	0	21 (33.9)
5	n _a	n _a	1	6	0	7 (11.3)
No. (%)	18 (29.0)	13 (20.9)	8 (12.9)	22 (35.5)	1 (1.6)	

^a Although 64 Chihuahuan Raven nests were detected on decommissioned telephone poles on WSMR, data were not collected for two nests.

^b Cross-arms are numbered from top down.

^c Percent occurrence of these five configurations among 338 decommissioned poles: 27.8, 26.3, 13.1, 28.6, and 6.8%, respectively

huahuan Ravens suggests selection for a particular pole configuration, although we did not specifically test preference. Both configurations were interspersed with single pole configurations. Configurations with two vertical poles may provide greater protection from wind and sun exposure than would single pole configurations. Nearly all nests, either occupied or unoccupied, were inside or be-

tween the two vertical poles. Only nine nests were placed on the outside of two-pole configurations, with one nest on the outside of a box-style configuration. By contrast, 135 nests were placed inside two-pole and box-style configurations.

On portions of WSMR where prevailing winds blow in the direction of the long axis of cross-arms, nests were placed on the leeward side of the pole

Table 3. Placement of 36 Chihuahuan Raven and 17 Swainson’s Hawk nests among cross-arms relative to vertical poles on three decommissioned telephone-line pole configurations in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.^a

CROSS-ARM No. ^b	NEST PLACEMENT BY POLE CONFIGURATION						TOTALS
	2X4		2X5		4X22		
	INSIDE ^c	OUTSIDE ^d	INSIDE	OUTSIDE	INSIDE	OUTSIDE	
Chihuahuan Raven							
1	0	0	0	0	0	0	0
2	4	0	9	1	0	0	14
3	3	0	3	0	0	0	6
4	5	1	3	0	0	1	10
5	n/a	n/a	6	0	0	0	6
Totals	12	1	21	1	0	1	36
Swainson's Hawk							
1	0	0	0	0	0	0	0
2	7	1	1	1	0	0	10
3	1	0	0	0	1	0	2
4	3	1	1	0	0	0	5
5	n/a	n/a	0	0	0	0	0
Totals	11	2	2	1	1	0	17

^a Only configurations with two or four vertical poles are included in this tabulation.

^b Cross-arms are numbered from top down.

^c Represents nests placed inside or between vertical poles.

^d Represents nests placed outside vertical poles.

Table 4. Percent of primary exposure directions among 61 Chihuahuan Raven and 26 Swainson's Hawk nests on decommissioned telephone-line poles in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.

PRIMARY EXPOSURE	PERCENT OF NESTS	
	CHIHUAHUAN	
	RAVEN (N = 61)	SWAINSON'S HAWK (N = 26)
North	3.3	7.7
Northeast	8.2	7.7
East	26.2	34.6
Southeast	19.7	0.0
South	8.2	7.7
Southwest	9.8	7.7
West	8.2	11.5
Northwest	16.4	23.1

relative to the origin of the winds. Nests, regardless of cross-arm, were placed against the poles in all cases, further suggesting some form of protection from wind or sun. Smith and Murphy (1982) suggested that raptor species tend to select nest sites with exposures that offer an optimum microclimate within reasonable variations. Steenhof et al. (1993) found Common Ravens nesting in the densest sections of steel electrical transmission line towers, and they speculated that nests in these sections

provided better protection from high winds that caused nest destruction in other sections of the towers.

We found no nests on the topmost cross-arm on telephone poles. Mosher and White (1976) indicated that exposure of young raptors to extreme temperatures and direct sun may be a major source of thermoregulatory stress during early stages of nestling development. Schmutz et al. (1984) found Swainson's and Ferruginous hawks preferred sheltered nest platforms relative to non-sheltered platforms in Alberta, Canada. Over half of the Swainson's Hawk nests and more than a third of Chihuahuan Raven nests detected on decommissioned telephone-line poles on WSMR were on cross-arm two. This may indicate selection of a high nest platform for prey detection and predator avoidance, while maintaining some protection from exposure.

Swainson's Hawks in southern New Mexico nest in a variety of vegetation cover types. Bednarz and Hoffman (1988) reported Swainson's Hawks nesting in large honey mesquite and soapberry trees among scrub habitat in southeastern New Mexico. Pilz (1983) described the habitat of Swainson's Hawks nesting in soaptree yuccas in southern New Mexico as sparsely covered by honey mesquite; however, black grama, hairy grama, and red three-awn (*Aristida oligantha*) grasslands occurred throughout the area.

Table 5. Percentage of vegetation cover types present in the area encompassed by all 3-km radius polygons surrounding 338 decommissioned telephone-line poles and poles with Chihuahuan Raven and Swainson's Hawk nests in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.

VEGETATION COVER TYPES	PERCENT VEGETATION COVER TYPE AMONG SPECIES AND POLE STATUS				
	CHIHUAHUAN		POLES WITH	POLES WITH	
	RAVEN NESTS (N = 64)	SWAINSON'S HAWK NESTS (N = 27)	UNOCCUPIED NESTS (N = 101)	NO NESTS (N = 140)	ALL POLES (N = 338)
Pinyon/juniper—Closed ^a	0.1	0.1	0.00	6.6	2.8
Pinyon/juniper—Open ^b	1.1	0.9	0.8	6.1	3.1
Mountain mahogany chaparral	0.7	0.1	0.4	1.9	1.1
Four-wing saltbush desert scrub	8.1	9.5	6.4	4.4	6.0
Creosotebush desert scrub	12.4	5.0	8.1	18.1	13.2
Honey mesquite desert scrub	48.3	62.8	61.6	36.4	47.9
Blue/hairy grama grassland	0.5	0.2	0.7	1.3	0.8
Black grama/dropseed grassland	23.3	17.6	17.1	19.9	19.8
Tobosa/giant sacaton grassland	1.9	3.7	1.6	0.5	1.4
Barren/rock outcrop/playa	4.6	0.2	3.2	4.7	3.8

^a Canopy cover >60%.
^b Canopy cover = 25% to 50%.

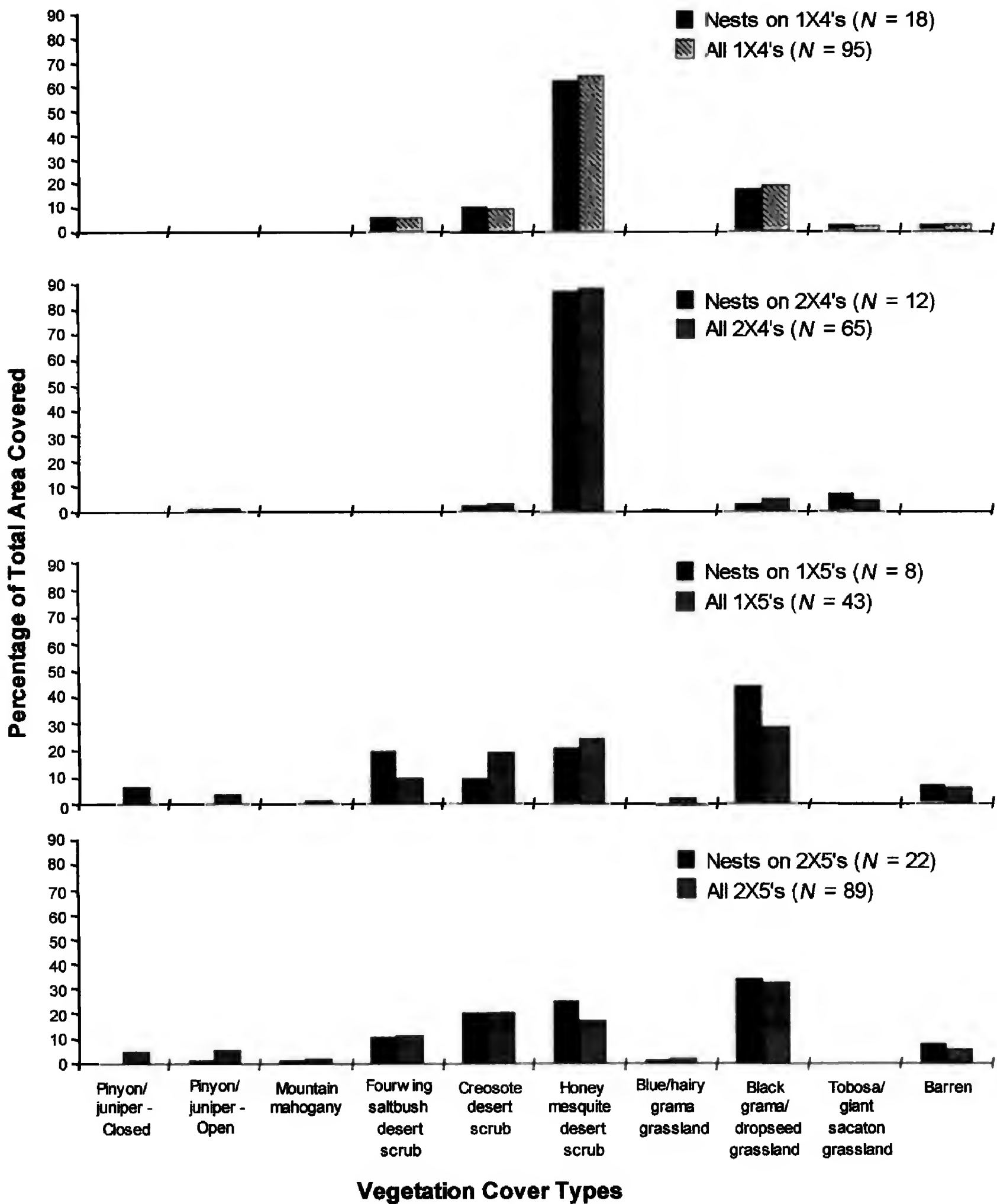


Figure 3. Percentage of total area for 10 vegetation cover types within 3-km of Chihuahuan Raven (CHRA) nests on two 5-cross-armed configurations of decommissioned telephone-line poles in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.

Table 6. Placement of 27 Swainson’s Hawk nests among cross-arms on five decommissioned telephone-line pole configurations in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.

CROSS-ARM NO. ^a	POLE CONFIGURATIONS					TOTAL (PERCENT)
	1X4 ^b	2X4	1X5	2X5	4X13	
1	0	0	0	0	0	0
2	6	8	2	2	0	18 (66.6)
3	1	1	0	0	1	3 (11.1)
4	1	4	0	1	0	6 (22.2)
5	0	0	0	0	0	0
Total (Percent)	8 (29.6)	13 (48.2)	2 (7.4)	3 (11.1)	1 (3.7)	
Percent occurrence of configuration among all poles (N = 338) ^b	28.1	19.2	12.7	26.3	6.8	

^a Cross-arms are numbered from top down.
^b Percent values do not account for 23 poles with configurations other than those included in table.

On WSMR, land cover within 3 km of all Swainson’s Hawk nests on decommissioned telephone-line poles was dominated by honey mesquite desert scrub. Furthermore, land cover within 3 km of the 2X4 telephone-pole configuration was 87.4% honey mesquite desert scrub compared to 63.5% for all 1X4s along the same route. The 1X4 pole configuration was interspersed among 2X4s along routes, however, fewer of these poles were used by Swainson’s Hawks as nest poles. This suggests that

for Swainson’s Hawks, pole configuration coupled with vegetation cover type are important features for nest site selection. Chihuahuan Ravens nested more often on 2X4 and 2X5 configurations than on 1X4 and 1X5 configurations even though the single pole configurations were interspersed among the two-pole configurations along routes, but there were no clear differences between used and unused poles. This suggests that Chihuahuan Ravens may select poles

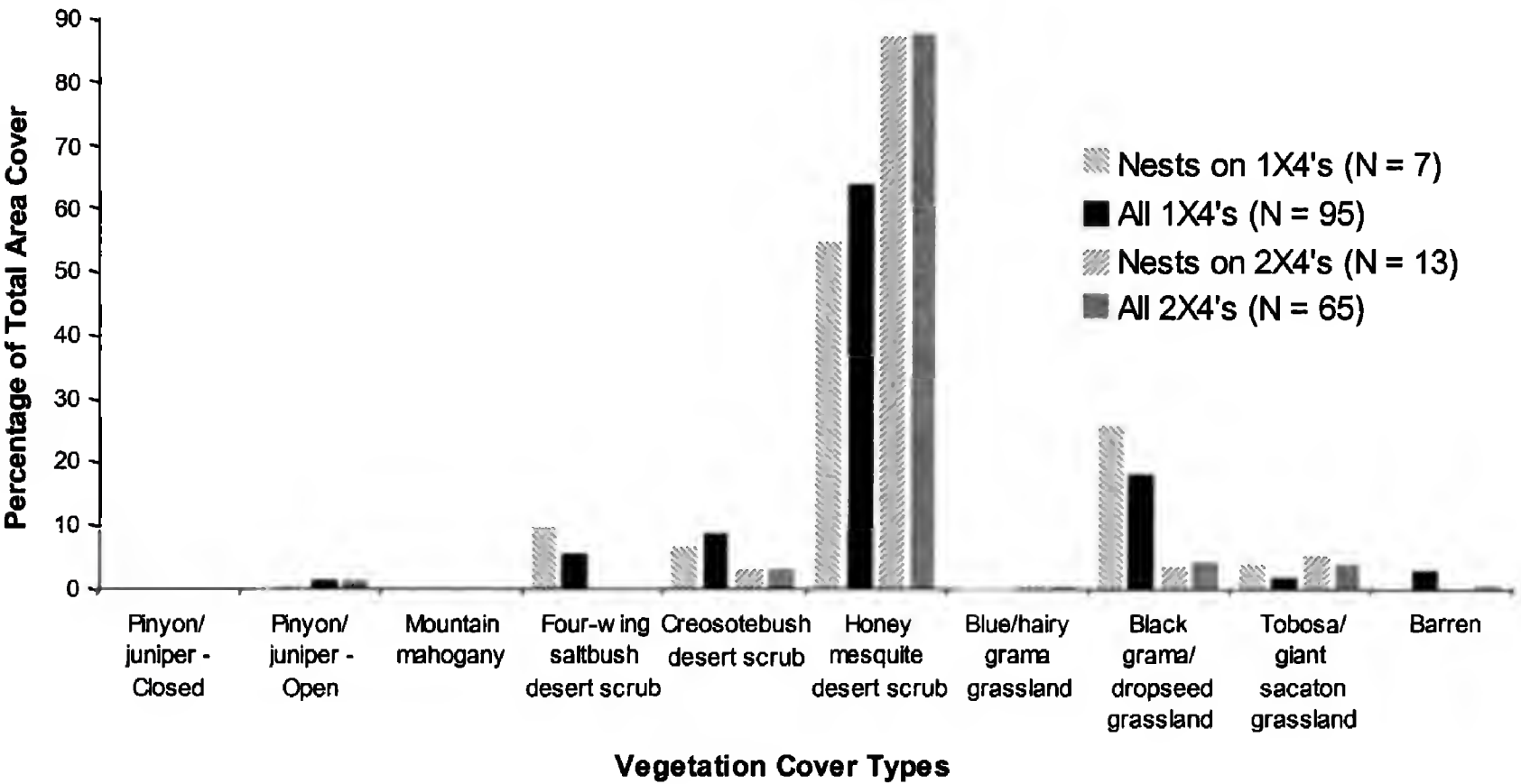


Figure 4. Percentage of total area for 10 vegetation cover types within 3-km of Swainson’s Hawk (SWHA) nests on two 4-cross-armed configurations of decommissioned telephone poles in the northern Chihuahuan Desert, White Sands Missile Range, New Mexico, 1997.

based on configuration rather than the land-cover around nest poles. The two-pole configurations probably afford better protection from exposure to wind and sun.

Box-style configurations on WSMR were suitable nesting platforms for raptors and Chihuahuan Ravens, with 8–22 paired cross-arms providing a dense assortment of potential nesting platforms. The 23 box-style configurations comprised 6.8% of the total available decommissioned poles on WSMR, but they supported 4.3% of nests. Box-style configurations may not be used readily for nest placement by raptors and Chihuahuan Ravens on WSMR for three reasons: (1) density of the configuration reduces visibility for detection of predators or intruding conspecifics; (2) predators capable of climbing, such as ring-tailed cats (*Bassariscus astutus*) or bobcats (*Felis rufus*), may be more apt to climb on these configurations successfully because of the dense supportive network of cross-arms; and (3) box-style configurations had telecommunication wiring criss-crossing inside the configuration. All one and two vertical pole configurations encountered on WSMR had the wiring removed. Box-style configurations still had wiring inside, and in some instances, outside the box, thus possibly creating obstacles to flight.

We examined essentially all (>97%) of the decommissioned telephone-line poles on WSMR during 1997, thus we considered these data to represent the effective population of poles and related nests rather than a sample. Further, nest structures on poles represent nest placement that has prevailed for several years. Therefore, we interpreted directly observed characteristics of poles and surrounding vegetation as indicative of nesting associated with the population of poles that year. We have not applied statistical tests because samples were not compared. We recognize that longer-term investigation can sample several breeding seasons and draw inferences about comparisons among years. Our inferences are biologically based on extensive observation of poles and nests overall, they are not grounded in specific statistical applications. Our subsequent statements of implications should be viewed with that perspective in mind.

CONSERVATION IMPLICATIONS

Decommissioned telephone-line poles and electrical poles are acceptable nesting sites for raptors and Chihuahuan Ravens in the northern Chihuahuan Desert. Before WSMR was established, Chi-

huahuan Ravens, Swainson's Hawks, Red-tailed Hawks, and Great Horned Owls probably nested on natural substrates and possibly on an occasional windmill. Since introduction of telephone and electrical poles, raptors and Chihuahuan Ravens have adapted to these substrates for nesting.

This investigation focused on raptors and Chihuahuan Ravens nesting on decommissioned poles. However, other avian species including Loggerhead Shrikes (*Lanius ludovicianus*), Western Kingbirds (*Tyrannus verticalis*), and Scott's Orioles (*Icterus parisorum*) also nested on these poles. Western Kingbirds and Scott's Orioles sometimes shared the same nest structure with Swainson's Hawks. Cavities in the vertical poles, possibly excavated by breeding Ladder-backed Woodpeckers (*Picoides scalaris*), have provided nest cavities for Ash-throated Flycatchers (*Myiarchus cinerascens*) and, possibly, Elf Owls (*Micrathene whitneyi*). Like snags in forests or saguaros (*Carnegiea gigantea*) in arid landscapes, these decommissioned poles are used by a variety of migratory species in the Chihuahuan Desert on WSMR. Removal of decommissioned poles could be detrimental to the present population of raptors and Chihuahuan Ravens nesting on these poles. If poles are removed, raptor and ravens may turn to nesting on structures used for testing operations on WSMR and, thus, become vulnerable to nest disturbance. Also, other birds associated with poles and raptor nests would be displaced.

We suggest that pole-management strategies be developed and implemented by land stewards in southwestern deserts with property where pole lines remain and may be altered or dismantled in the future. Such strategies should provide for protection, maintenance, and prospective replacement of important pole structures. We found that Swainson's Hawks used 2X4 pole configurations disproportionate to other configurations available. Management options for Swainson's Hawks nesting on poles likely are benefited by maintenance and retention of the 2X4 configuration as a nest platform for this species where suitable natural substrates are limited or absent.

To increase potential use of poles by birds, pole salvage operations in the southwest should strive to retain poles with two or more sets of paired cross-arms. These sets of cross-arms should be placed one above the other to provide a suitable nesting platform and shade structure for raptors and Chihuahuan Ravens.

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SHORT COMMUNICATIONS

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AERIAL TELEMETRY ACCURACY IN A FORESTED LANDSCAPE

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KEY WORDS: *aerial telemetry; geographic information system; radiotelemetry; telemetry error.*

Radiotelemetry is one of the more widely used tools for investigations of animal movements, home range size, habitat use, and survival. Radiotelemetric estimations of animal locations, however, are not without error. Bearing errors associated with ground-based triangulated estimates of radio-tagged animals can be in excess of 20 degrees (Hupp and Ratti 1983, Garrott et al. 1986), and depending on the aim of the study, excessive error may preclude meaningful analyses of data (White and Garrott 1990). Some researchers have chosen to ignore the issue of error in telemetry data (see Hupp and Ratti 1983, Saltz 1994, Withey et al. 2001), but ultimately the value of telemetry data is severely diminished when the magnitude of error is not investigated.

Aerial tracking may be more desirable than ground-based methods in studies involving telemetry of wide-ranging birds and other highly-mobile animals, or in dense forests where signal “bounce” may limit the effectiveness of ground-based telemetry (Gilmer et al. 1981, Marzluff et al. 1994). Aerial tracking allows researchers to avoid much of the potential error associated with ground-based tracking because fewer obstructions lie between the receiver and transmitter. However, aerial telemetry does not always provide “line of sight” radio fixes, especially in heavily forested landscapes. Although many studies have elucidated environmental factors contributing to bearing error from ground-based telemetry, no studies have documented how environmental factors influence conventional aerial telemetry accuracy.

In this study, we evaluated the accuracy, precision, and sources of error for an aerial telemetry protocol designed for investigations of home range size and movement patterns of raptors and other wide-ranging birds at a heavily forested site in South Carolina, U.S.A. At this site, ground-based telemetry for wide-ranging animals is impractical due to substantial forest cover and extensive roadless areas.

METHODS

Study Area. This study was conducted at the 78 000 ha Savannah River Site (SRS), near Aiken, South Carolina. The SRS is a nuclear facility owned and operated by the United States Department of Energy, and is designated as a National Environmental Research Park. Approximately 64% of the SRS has been planted in loblolly pine (*Pinus taeda*), longleaf pine (*P. palustris*), and slash pine (*P. elliottii*, Workman and McLeod 1990), which are managed for timber production by the United States Forest Service. An additional 15% of the land cover is classified as bottomland hardwood (Workman and McLeod 1990). Although most of the SRS is forested, there are several industrial areas located throughout the site. Overhead powerlines of various sizes are present near industrial areas and along major roads. Elevation at the SRS ranges from 30 masl or less on the southwestern portion of the site near the Savannah River to 115 m on the northern portion of the site (White and Gaines 2000).

Field Procedures. Transmitters (Holohil Systems Ltd, Model AI-2B, 164–165 MHz) were attached to small trees or wooden stakes 1 m from ground level at 25 locations throughout the SRS. We placed transmitters (hereafter, beacons) arbitrarily in locations that varied with respect to habitat type and distance from overhead powerlines. We considered four habitat types, which were determined by visual inspection and by referencing a digital habitat map of the SRS (Wiggins-Brown et al. 2000): tree-

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less habitat ($N = 3$ beacons), open-canopy pines (12), closed-canopy pines (4), and deciduous hardwoods (6). The number of beacons placed in each habitat type roughly corresponded to the relative proportion of each habitat type on the SRS. Distances between beacons and the nearest overhead powerline ranged from 26–5477 m ($\bar{x} = 1438$; $SD = 1620$). Beacon locations were recorded in Universal Transverse Mercator (UTM) coordinates with a Trimble Pro XR Global Positioning System (GPS) unit (sub-meter accuracy).

We used a Cessna 172 airplane equipped with two-element Yagi antennas attached to each wing strut to estimate beacon locations (Gilmer et al. 1981). Beacon locations were estimated during three, 2-hr flights during the spring of 2001 after peak leaf emergence (10, 20, and 24 April). The same pilot, observer, and aircraft performed all flights. We generally flew 60–180 m from ground level at an air speed of 140–175 km/hr. We estimated beacon locations with a Garmin 12 CX handheld GPS unit (10–30 m accuracy; see Marzluff et al. 1994 for further description of aerial telemetry methods). We estimated beacon locations in random order. The pilot and observer were blind to beacon locations; they were given only a list of radio frequencies and had no prior knowledge of their placement. We generally followed steps outlined in Samuel and Fuller (1996) for aerial telemetry: once a signal was detected, the observer indicated the general direction of that signal to the pilot. An attempt then was made to keep the signal on one side of the airplane while circling the signal source. A visual estimate of the beacon location was made after circling the signal source several times and monitoring signal strength. We then flew directly over the estimated location and recorded the UTM coordinates with the GPS unit.

Data Analyses. UTM coordinates of actual and estimated beacon locations were imported into a Geographic Information System (GIS; ArcView 3.2; Environmental Systems Research Institute, Inc., Redlands, CA) as point themes (Fig. 1). The GIS was used to determine the distances from actual beacon locations to estimated locations, and the distances from actual beacon locations to the nearest overhead powerline. It was not necessary to correct linear distances with respect to topography due to the relative uniformity of the terrain at the scale of the measured distances.

We examined the effects of habitat at the beacon location and proximity of the nearest overhead powerline on linear accuracy of location estimates. Linear accuracy was defined as the distance between the actual beacon locations and the locations estimated with the handheld GPS from the airplane. We used one-way analysis of variance to test whether the habitat within which the beacon was located influenced the linear error of estimates. The LSD procedure (SPSS 1999) was used for pair-wise *post hoc* comparisons between variables. We used simple linear regression to examine the influence of the proximity of the nearest overhead powerline to beacon locations on linear error. Confidence areas (95%) were computed by centering a circle with a radius of $(1.96) \times (SD \text{ of the linear estimate of error})$ at beacon location estimates (White and Garrott 1990). All analyses were performed using SPSS 10.0 (SPSS 1999).

RESULTS

We located 24 of the 25 beacons (96%) from the air. Location of one beacon was confounded by interference on its frequency from other sources on the SRS; this beacon was excluded from the analyses. Mean linear distance error for the 24 location estimates was 191 m (range = 22–1011 m, $SD = 197$ m; Table 1). The 95% confidence circles were 47 ha in size (Fig. 1). Twenty-two of 24 (92%) of the actual beacon locations fell within the confidence circles. One-way analysis of variance showed that linear error differed among habitat types ($P = 0.02$). *Post hoc* comparisons indicated linear error differences between beacons placed in deciduous hardwoods (\bar{x} error = 401 m) and each of the other three habitat types (open pine, 117 m; dense pine, 130 m; treeless habitat, 124 m). The proximity of overhead powerlines to beacons had no discernable influence on linear error ($R^2 = 0.05$, $P = 0.32$).

DISCUSSION

According to Samuel and Fuller (1996), "... few data are available from tests of the precision and accuracy of aerial radio-tracking, but ± 100 –200 m is probably the best commonly achieved accuracy." Marzluff et al. (1994) reported a mean linear error of 409 m, with an associated 95% confidence circle of 112 ha around each point estimate. Carrel et al. (1997) used several location-recording methods to achieve linear errors of 73–386 m at unknown beacon locations. Hoskinson (1976) reported a linear error of 7–70 m with two different pilots, but he flew exceedingly slowly (95–115 km/hr), dangerously low to the ground (15–30 m from ground level), and circled each beacon for at least 5 min. Hoskinson's (1976) results probably reflect the minimum error possible for aerial telemetry with conventional equipment, but his methods were unrealistic for most research situations.

In all radio-tracking studies, the required level of accuracy depends on the study objectives. Our mean linear error of 191 m and the associated 95% confidence circles of 47 ha are probably sufficient for investigations of home range and local movement patterns of wide-ranging species, although this level of accuracy would be inadequate for many fine-scale analyses. For example, Coleman and Fraser (1989) reported annual home range sizes of 14881 ha for Black Vultures (*Coragyps atratus*) and 37072 ha for Turkey Vultures (*Cathartes aura*) in Pennsylvania and Maryland. Home range estimates for Ferruginous Hawks (*Buteo regalis*) have exceeded 9000 ha in south-central Washington (Leary et al. 1998). Our error rates would be relatively inconsequential when examining home range size and broad-scale movements of such birds. However, depending on habitat heterogeneity, an accurate description of microhabitat use at specific time intervals probably would not be possible.

Whereas factors such as pilot skill and attitude (Hoskinson 1976), wind speed (Hoskinson 1976, T. DeVault pers. observ.), and airplane altitude and speed (Caughley 1974) are known to influence aerial telemetry accuracy,

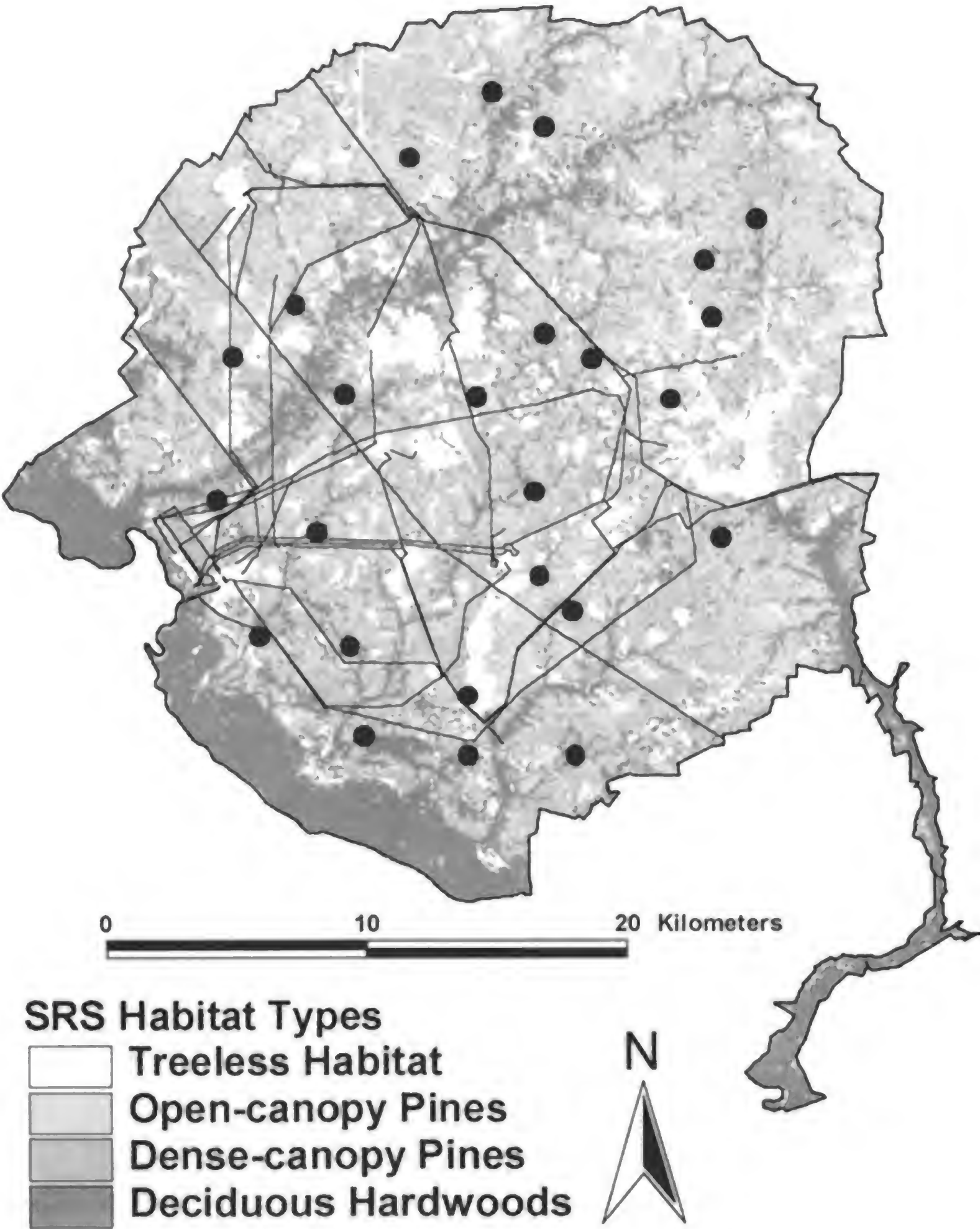


Figure 1. Map of the Savannah River Site, South Carolina, depicting major habitat types, location of overhead powerlines (thin lines) and beacon locations (solid circles). The circles representing beacon locations also represent the relative size of the confidence circles (47 ha). This figure was modified from a 1999 digital habitat map (30 m resolution) with 33 original habitat types (Wiggins-Brown et al. 2000).

Table 1. Mean linear distance error and coverage by major habitat type of beacon locations estimated with aerial telemetry.

HABITAT TYPE (N)	MEAN LINEAR DISTANCE ERROR	SE	COVERAGE ^a
Treeless habitat (3)	124	54.3	100
Open-canopy pines (11)	117	15.1	100
Closed-canopy pines (4)	130	26.2	100
Deciduous hardwoods (6)	401	127.9	67
Total (24)	191	40.3	92

^a Percentage of actual beacon locations that fell within confidence circles.

our data indicate that the forest type within which a transmitter is located also can influence accuracy, and should be considered when assessing aerial telemetry accuracy. Rempel et al. (1995) and Rumble and Lindzey (1997) demonstrated that forest type and tree density affected GPS collar observation rate and accuracy, so it follows that signal bounce from vegetation could influence accuracy of conventional transmitters detected by aerial telemetry as well. Conversely, our results do not support evidence that the presence of overhead powerlines decreases telemetry accuracy (Withey et al. 2001). However, due to low sample sizes, we were unable to examine the influence of powerlines on mean linear error within each habitat type, even though we found differences in mean linear error across habitat types. Thus, this analysis may be somewhat unreliable.

Marzluff et al. (1994) expressed concern about the ability of aerial telemetry to accurately represent movements and home ranges of Prairie Falcons (*Falco mexicanus*) because the researchers often could not obtain radio fixes until the birds were perched, and often already back at their nests. Pilot studies at the SRS have shown that this problem does not exist to a large extent when tracking soaring birds, like buteo hawks and vultures (T. DeVault unpubl. data). Such birds move throughout their home ranges much more slowly than falcons, facilitating rapid and unbiased location estimates. However, we tested only stationary beacons, thus our results may not be applicable to moving instrumented birds. Furthermore, it should be noted that the inferential value of our data may be limited because we did not place beacons randomly throughout the study site.

Our study suggests that aerial telemetry is an effective method for some radio-tracking applications in areas where ground-based methods are not feasible due to extensive forest cover and the need for large distances between receiver and transmitter (i.e., when tracking wide-ranging birds). Although aerial telemetry does not provide completely unobstructed paths from the transmitter to the receiver, it appears that the obstructions do not influence the quality of the radio signal to a large extent, even in heavily forested landscapes.

RESUMEN.—Evaluamos la precisión y las fuentes de error de la telemetría aérea en la zona boscosa del Rio Savannah en Carolina del Sur, U.S.A. Los radiotransmisores fueron ubicados en 25 localidades en un sitio de 78.000 ha. Usamos un aeroplano/avión Cessna 172, equipado con antenas duales para localizar los transmisores. El error medio lineal para telemetría aérea fue de 191 m, y el círculo de confianza del 95%, fue de 47 ha. Veintidós de 24 (92%) de las localidades actuales de los transmisores estuvieron dentro del círculo de confianza. El tipo de hábitat influenció la precisión aérea: el error lineal entre las localidades de transmisores actual y estimada, fue mayor para los transmisores ubicados en bosques deciduos y en otros tipos de hábitats. La proximidad de líneas de energía no tuvo un efecto significativo en la precisión de la telemetría aérea. Especialmente en hábitats de bosques densos, la telemetría aérea provee una alternativa precisa y práctica a la telemetría en tierra.

[Traducción de César Márquez]

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PERCH-SITE SELECTION AND SPATIAL USE BY CACTUS FERRUGINOUS PYGMY-OWLS IN SOUTH-CENTRAL ARIZONA

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KEY WORDS: *Ferruginous Pygmy-Owl*; *Glaucidium brasilianum*; cactorum; Altar Valley; Arizona; endangered species; habitat selection; perch site.

Cactus Ferruginous Pygmy-Owls (*Glaucidium brasilianum cactorum*) are federally endangered in Arizona and therefore of significant conservation and management interest (U.S. Fish and Wildlife Service 1997). Concern for pygmy-owls has resulted in major efforts in conser-

vation planning including a focal role in the Sonoran Desert Conservation Plan, proposed designation of critical habitat, and recent release of a Draft Recovery Plan by the U.S. Fish and Wildlife Service (USFWS 2002, 2003). Descriptions of areas occupied by pygmy-owls in Arizona are limited to anecdotal accounts from the late 1800s and early to mid 1900s (e.g., Fisher 1893, Breninger 1898, Gilman 1909, Phillips et al. 1964), a recent study by Richardson (2000), and unpublished reports. No published information exists on characteristics and size of areas used by pygmy-owls in semidesert grasslands in Arizona.

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Information on habitat selection and composition of areas used by pygmy-owls is important for recovery efforts, guiding development and land-use activities, and prioritizing prospective conservation reserves. My objectives were to compare conditions at and around calling perches used by pygmy-owls with the surrounding environment, and describe the size, shape, and composition of occupied areas.

METHODS

Study Area. The Altar Valley (centered at 31°40'N, 111°20'W) is southwest of Tucson, Arizona and bordered by Mexico to the south, State Highway 86 to the north, and eight mountain ranges to the east and west. Vegetation consists primarily of semidesert grassland ranging from open savannah to shrub-invaded thornscrub and woodland (Brown 1982). Woodlands of mesquite (*Prosopis velutina*) and catclaw acacia (*Acacia greggii*) are common along drainages. Upland vegetation consists of semidesert grassland, desertscrub, thornscrub, oak (*Quercus* sp.) woodland, and oak savannah. Broadleaf trees other than netleaf hackberry (*Celtis reticulata*) and saguaro cacti (*Carnegiea gigantea*) are rare in the southern and central portions of the valley. The study area included the Buenos Aires National Wildlife Refuge (NWR), Arizona State Trust land, and private land.

Site Location and Home Range Delineation. Between March and May 1999, I surveyed ca. 8300 ha in the southern and central Altar Valley using recorded, conspecific territorial calls to elicit responses from pygmy-owls. I documented seven areas and four nests occupied by pygmy-owls. I revisited four of these areas between April and August 1999 to locate perch sites, assess size and shape of home ranges, and measure features at and around substrates used for calling and randomly-selected substrates.

I visited occupied areas during early mornings and evenings when pygmy-owls are most active and vocal (Proudfoot and Johnson 2000). During each visit, I marked the perch substrate where I initially detected a pygmy-owl and recorded time, date, sex, and activity. I determined sexes by the type of vocalization, duration of calling, and behavior of owls (Proudfoot and Johnson 2000). During visits when owls were exceptionally active (moved every 1–10 min and used >5 perches), I also marked an additional substrate used 30 min after owls left sites where I detected them initially. I did not solicit responses or flush owls during visits. I mapped perch sites as points on topographic maps and determined their coordinates with a global positioning system (GPS) receiver. I calculated minimum convex polygons (MCP) that included all perch sites to estimate the size and shape of home ranges (Mohr and Stumpf 1966). I generated and visited random coordinates within each MCP and marked the nearest potential perch substrate (woody plant or saguaro cavity ≥ 2 m tall). Although three of four males were banded, my observations suggested that only one male occupied each home range.

Vegetation Measurements. I measured vegetation features around perch substrates used for calling and random substrates at three spatial scales: perch substrate, microhabitat, and mesohabitat. I recorded species of

each substrate, measured height with a clinometer or measuring pole, and basal diameter with a tape. For colonial shrubs with multiple stems, I measured basal diameter of each cluster of stems including open space. I measured canopy diameter of each substrate by averaging the widest horizontal canopy dimension with a perpendicular measurement across the canopy. I measured distance from the base of each substrate to closest drainage and classified the vegetation community around substrates as woodland (xeroriparian vegetation along drainage), savannah (scattered trees), grassland (open with occasional tree), or desertscrub (in rocky uplands).

To quantify vegetation at the microhabitat scale, I measured vegetation within 0.003-ha circular plots (3-m radius) centered on perch and random substrates. I recorded distance to, and height of, nearest woody or succulent plants ≥ 3 m tall in four, 90° quarters denoted by the cardinal directions (Cottam and Curtis 1956). Within each plot, I recorded species, height, and basal diameter of all woody trees, shrubs, and succulents ≥ 2 m tall rooted within plots and listed other woody species present. I used a vertical line-intercept method (Mills et al. 1991) to measure vegetation cover and volume. Six, 3-m transects, based on a random bearing and radiating 60° apart were used per plot. I placed a 17-mm diameter pole at 1-m intervals along transects and recorded decimeter intervals with vegetation (any rooted plant material) within 5 cm of the pole. I also recorded ground cover (litter, bare ground, grass, forb, or rock) and all woody or succulent species present within four vegetation strata (0–0.5 m groundcover, 0.51–2 m midstory, 2.01–5 m low canopy, 5+ m high canopy). I used these data to calculate total vegetation volume, vegetation volume within 1-m strata, percent vegetation cover in four strata, and ground cover.

To quantify vegetation at the mesohabitat scale, I measured vegetation within 0.07-ha circular plots (15-m radius) around four to five randomly-selected perch substrates per home range. I only described vegetation in desertscrub and woodland communities because pygmy-owls rarely used grassland or savannah. Methods were similar to those described for 0.003-ha plots, but arrangement and quantity of vertical line-intercept samples differed. I placed eight 15-m transects 45° apart and placed the pole 2.4, 8.9, 12.1, and 14.6 m from center points. Line-intercept points were spaced unevenly to reduce over-sampling plot centers. All other measurements followed 0.003-ha plot protocols.

Analyses. I used all perch sites and a GPS receiver to measure area, perimeter, and maximum length of home ranges. I compared used and available resources to measure habitat selection by pygmy-owls (Manly et al. 1995). I used nonparametric procedures (Kruskal-Wallis) to test for differences in vegetation conditions (Daniel 1978). To test for selection of common perch species and vegetation communities, I used Pearson's Chi-square goodness-of-fit tests (Sokal and Rohlf 1995). I used stepwise ($P < 0.25$ to enter, $P < 0.10$ to remain) discriminant function analysis (DFA) to determine which combination of 29 variables best discriminated between used and random sites. I then used canonical DFA on selected variables and canonical scores (CS) to determine which variables accounted for most discriminatory power. I tested

Table 1. Spatial metrics of four cactus Ferruginous Pygmy-Owl home ranges, Altar Valley, Arizona, 1999.

VARIABLE	MALE 1	MALE 2	MALE 3	PAIR	MEAN	SE
No. of locations	24	27	15	25	22.8	2.7
Area (ha)	9.9	11.7	47.3	18.5	21.9	8.7
Perimeter (m)	1743	1830	3193	2832	2400	391
Maximum distance between points (m)	783	803	1359	1347	1073	162

the model's explanatory ability with multivariate analysis of variance (MANOVA). When necessary, variables were transformed using $\log(x)$ or $\log(x + 1)$ to better meet assumptions of parametric procedures (Sokal and Rohlf 1995). I performed univariate comparisons separately for each individual and multivariate analysis for all individuals combined.

RESULTS

Between 10 April and 15 August 1999, I made 83 visits to four home ranges, three occupied by unpaired males and one by a nesting pair. Unpaired males vocalized on 96, 71, and 67% of visits and the paired male on 56% of visits.

Home Ranges. A total of 24, 27, 15, and 25 perch sites were located within each home range. Home ranges averaged 21.9 ha in area ($SE = 8.7$) and ranged from 9.9–47.3 ha (Table 1). Three home ranges were distributed along large drainage segments where maximum distance between sites ranged from 783–1347 m ($\bar{x} = 978$, $SE = 185$). A fourth home range comprised four smaller drainages 160–375 m apart. The female was always observed within 950 m of the nest, but remained within ca. 150 m throughout incubation. All home ranges were occupied throughout the study period except for the largest, where the male was last detected on 11 June.

Three home ranges included one or more linear stands of xeroriparian woodland dominated by mesquite and catclaw acacia, mesquite-savannah on flats above woodlands, and desertscrub restricted to rocky uplands on one side. A fourth home range comprised semi-mesic riparian woodland dominated by ash (*Fraxinus velutina*), mesquite, catclaw acacia, netleaf hackberry, and red barberry (*Berberis haematocarpa*). Two home ranges included a dry water catchment or corral. The one nest was located in an ash tree along the main drainage.

Microhabitat Selection. I located 27, 18, and 13 perch substrates used for calling and 31, 29, and 30 random substrates within home ranges occupied by single males. I did not measure sites for the paired male due to a limited number of calling perches ($N = 9$). Pygmy-owls did not use vegetation communities in proportion to availability within all home ranges ($\chi^2 \geq 7.22$, $P \leq 0.027$) (Fig. 1). Woodlands were used in greater proportion ($\chi^2 \geq 4.01$, $P \leq 0.045$), whereas savannah was used less than expected ($\chi^2 \geq 6.91$, $P \leq 0.009$). Desertscrub was used in proportion to availability ($\chi^2 \leq 2.36$, $P \geq 0.124$).

Perch substrates were taller and had larger basal and canopy diameters than random substrates within all home ranges ($\chi^2 \geq 8.55$, $P \leq 0.003$; Table 2). Use of perch species was disproportionate to availability in one home range ($\chi^2 = 11.36$, $P = 0.078$), but not in the other two ($\chi^2 \leq 8.16$, $P \geq 0.226$). Pygmy-owls used mesquite, saguaro, blue paloverde (*Cercidium florida*), ocotillo (*Fouquieria splendens*), catclaw, and whitethorn acacia (*Acacia constricta*) for calling perches. Mesquite was used for 70–92% of perches overall and 93–100% of perches in woodlands, but mesquite use reflected availability ($\chi^2 \leq 1.97$, $P \geq 0.160$). Male pygmy-owls called from inside saguaro cavities during six visits (7.8%) and were observed roosting in these same cavities during day and night.

Total vegetation volume and vegetation volume >2 m above ground were greater around perch substrates within all home ranges ($\chi^2 \geq 4.44$, $P \leq 0.035$). Vegetation volume 0–1 m above ground averaged 18.7% greater around random sites in two home ranges ($\chi^2 \geq 3.60$, $P \leq 0.058$), but only 9.5% greater in the other ($\chi^2 = 1.42$, $P = 0.23$). Vegetation volume 1–2 m above ground did not differ from random sites ($\chi^2 \leq 1.39$, $P \geq 0.24$). Microhabitat around perch substrates had greater plant species richness, and higher density and basal area of plants ≥ 2 m tall ($\chi^2 \geq 3.38$, $P \leq 0.066$); these patterns were mostly significant. Ground cover around perch substrates tended to have more litter and less bare ground than random sites (Table 2). Perch substrates were 2.9 times closer to drainages ($\bar{x} = 29.2$ m, $SE = 10.5$) in one home range, where cover of upland desertscrub was limited. Within other home ranges, perch substrates outside of desertscrub averaged only 6.3 ($SE = 1.1$) and 6.4 m ($SE = 1.5$) from drainages. All perch substrates were within 160 m of a drainage.

Height, basal and canopy diameters, mean distance to nearest neighbor plants, distance to drainage, vegetation volume 1–2 m and >6 m above ground, density of trees and shrubs, and ground cover of grass and bare ground discriminated calling perches from random sites (Wilk's $\Lambda = 0.346$; $df = 10$, 137; $P < 0.0001$). Factors that accounted for most variation in the model included perch substrate height ($CS = 2.09$), perch basal diameter ($CS = 1.12$), and density of trees and shrubs ($CS = 0.64$).

Mesohabitat. Occupied woodlands ($N = 11$ plots) had an open to semi-open canopy of mesquite, catclaw acacia, and, occasionally, blue paloverde; moderate cover 2–5 m

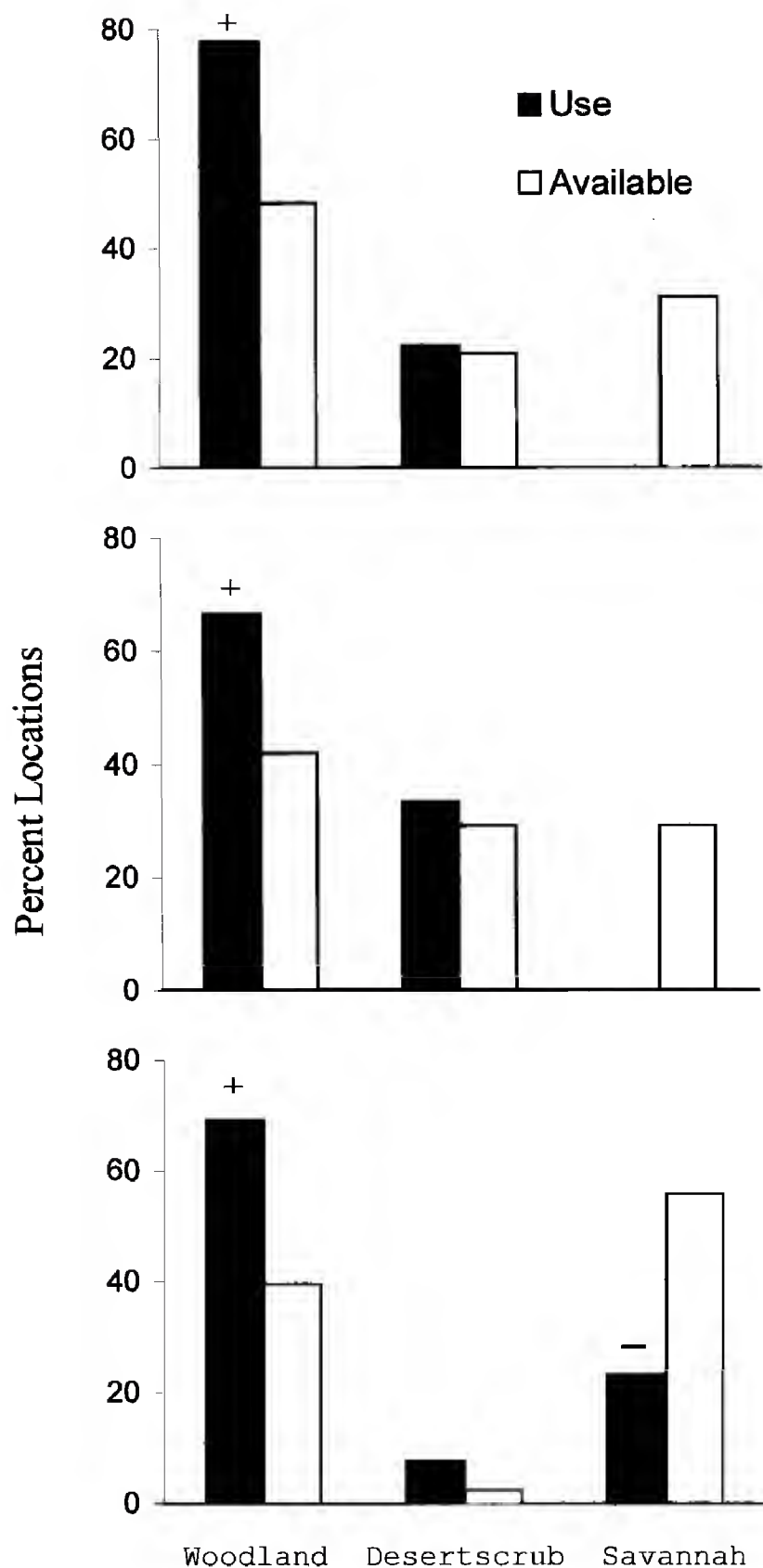


Figure 1. Use and availability of vegetation communities around perch substrates used for calling within three cactus Ferruginous Pygmy-Owl home ranges, Altar Valley, Arizona, 1999. "+" indicates use > expected ($P < 0.05$), "-" indicates use < expected, and no sign indicates no difference.

above ground ($\bar{x} = 49.9\%$, $SE = 3.7$, range = 30–64), and low cover above 5 m ($\bar{x} = 7.9\%$, $SE = 3.2$, range = 0–27). Woodlands had moderate cover 0.5–2 m above ground ($\bar{x} = 59.3\%$, $SE = 2.2$, range = 48–76) composed mainly of desert hackberry (*Celtis pallida*), wolfberry (*Lycium* sp.), catclaw acacia, mesquite, graythorn (*Ziziphus obtusifolia*), and cholla (*Opuntia* sp.). Desert hackberry

and wolfberry often formed scattered patches of dense midstory vegetation under larger trees (Table 3). Cover 0–0.5 m above ground was moderately high ($\bar{x} = 71.4\%$, $SE = 2.2$, range = 61–81) and often composed of grass. Ground cover was composed mainly of bare ground ($\bar{x} = 54.0\%$, $SE = 3.6$), litter ($\bar{x} = 31.3\%$, $SE = 3.1$), and grass ($\bar{x} = 9.8\%$, $SE = 3.1$).

Upland desertscrub ($N = 3$ plots) was dominated by ocotillo and blue paloverde (Table 3). Adult saguaros were present in or immediately around all plots and harbored cavities. Desertscrub plots had high cover below 0.5 m above ground ($\bar{x} = 88.0\%$, $SE = 1.7$, range = 85–91), moderate cover 0.5–2 m ($\bar{x} = 49.7\%$, $SE = 6.9$, range = 36–58), and low cover above 2 m ($\bar{x} = 10.0\%$, $SE = 2.0$, range = 0–12). Ground cover was composed mainly of rock ($\bar{x} = 66.0\%$, $SE = 12.7$), bare ground ($\bar{x} = 15.7\%$, $SE = 4.7$), and litter ($\bar{x} = 13.3\%$, $SE = 5.9$).

DISCUSSION

Spatial use by these four pygmy-owls conformed to the arrangement of landscape and vegetation features within home ranges. Woodland size and shape appeared to correspond with home range boundaries and was less developed outside of home ranges on both upstream and downstream sides. The largest home range may have been underestimated because the male was not detected after 11 June. In Texas, area used (based on MCP) by nine paired males from one week before to one week after incubation ranged from 1.3–23.1 ha, whereas an unmated male used 110 ha during the same period (Proudfoot and Johnson 2000). Additionally, five families (adults and three fledglings/family) used from 9.3–59.5 ha between fledging and dispersal. In Arizona, preliminary estimates of three home ranges used during the 1998 breeding season (based on MCP) were 8.1, 14.2, and 89.0 ha (Arizona Game and Fish Department unpubl. data).

Perch substrates used for calling were generally the largest trees available. Although heights of calling locations within substrates were not measured, observations indicated that owls often called from the upper third of substrates. Calling from near the tops of large trees is likely more audible than when closer to the ground. Selection of elevated calling perches has been documented for other bird species (Knopf et al. 1990) and likely promotes advertisement to females and aids in territorial maintenance and defense. Calling from inside saguaro cavities may aid in advertisement of potential nest cavities to females (Proudfoot and Johnson 2000).

Saguaros and upland desertscrub are rare in the southern and central Altar Valley, but presence of these types within three home ranges augmented diversity of vegetation and habitat features. Cavities of sufficient size for nesting were rare in woodland trees except where large broadleaf species were present. Cavities created by Gila Woodpeckers (*Melanerpes uropygialis*) and Gilded Flickers (*Colaptes chrysoides*) were rare except in saguaros. Presence of large columnar cacti also appears to be a key

Table 2. Means and standard errors for habitat variables at and around calling perches (0.003 ha plots) of cactus Ferruginous Pygmy-Owls ($N = 3$) and random sites within home ranges, Altar Valley, Arizona, 1999. Means and standard errors based on $N = 27, 18$, and 13 used, and $N = 31, 30$, and 29 available plots.

SCALE VARIABLE	USED		AVAILABLE		<i>P</i> < 0.05 ^a
	MEAN	SE	MEAN	SE	
Perch substrate					
Height (m)	5.6	0.6	3.2	0.1	3
Basal diameter (cm)	17.8	0.7	8.8	0.6	3
Canopy diameter (m)	6.8	0.3	4.0	0.2	3
Distance to drainage (m)	31.8	2.2	47.1	19.3	0
Microhabitat					
Ground cover bare (%)	22.6	0.9	39.7	5.6	3
Litter	57.4	7.9	36.3	1.1	2
Grass	5.6	2.7	11.7	2.8	0
Total veg. volume (hits)	245.6	17.1	160.9	10.3	3
Veg. volume 0–1 m	61.1	4.1	71.9	1.2	1
1–2 m	50.6	1.2	45.7	2.8	0
2–3 m	57.9	5.6	26.3	1.5	3
3–4 m	37.8	3.5	9.4	2.2	3
4–5 m	20.9	4.5	5.6	2.6	3
5–6 m	10.9	5.8	2.4	1.3	3
>6 m	6.6	6.3	0.7	0.6	1
Density ^b (no.)	3.4	0.4	1.3	0.2	3
Height ^b (m)	2.5	0.1	1.6	0.1	2
Basal diameter ^b (cm)	19.4	3.4	7.9	1.4	2
Plant sp. richness (no.)	6.6	0.2	4.8	0.7	3
Nearest neighbor height (m)	4.1	0.1	3.8	0.1	1
Distance (m)	7.0	1.3	11.1	1.2	2

^a Number of three possible comparisons within home ranges where $P < 0.05$.

^b Plants ≥ 2 m tall.

Table 3. Density and height of vegetation in 0.07-ha plots centered on perch substrates in three cactus Ferruginous Pygmy-Owl home ranges, Altar Valley, Arizona, 1999.

SPECIES	WOODLAND ($N = 11$)				DESERTSCRUB ($N = 3$)			
	DENSITY ^a		HEIGHT (M)		DENSITY ^a		HEIGHT (M)	
	MEAN	SE	MEAN	SE	MEAN	SE	MEAN	SE
Mesquite	12.5	1.9	3.9	0.2	1.0	0.6	2.6	0.4
Catclaw acacia	16.4	2.5	2.8	0.1				
Blue paloverde	2.3	0.5	3.8	0.4	4.3	2.0	2.6	0.1
Wolfberry	3.1	0.8	2.4	0.1	3.0	1.2	2.2	0.1
Desert hackberry	10.2	3.0	3.2	0.2				
Graythorn	1.2	0.4	2.6	0.2				
Whitethorn acacia	0.8	0.4	2.8	0.4	1.7	1.7	2.3	0.1
Saguaro					2.3	1.5	6.5	0.5
Cholla	1.9	0.5	2.7	0.2	0.3	0.3	2.0	2.0
Ocotillo					27.0	2.5	3.0	0.1
All species	47.9	6.0	3.2	0.1	40.0	2.5	3.1	0.1

^a Mean number of individuals within 0.07-ha plots.

factor that influences pygmy-owl distribution in neighboring Sonora, Mexico (Flesch 2003).

Vegetation cover in occupied woodlands was moderate and patchy, and vegetation volume near the ground was often moderate around perch substrates. This structure provided good horizontal and vertical visibility that may be important for the perch-and-pounce or sit-and-wait hunting strategies of pygmy-owls. Woodlands along drainages provided cover for hunting, roosting, and escape, whereas saguaros and desertscrub vegetation in uplands contributed potential nest and roost cavities and cover. Although this study focused on selection of features at and around calling perches, I observed pygmy-owls using many of these same patches of vegetation for hunting and roosting. Therefore, I suspect these same vegetation patches are important for other aspects of pygmy-owl life history. Management of pygmy-owls in the areas studied should stress retention of large trees, structurally diverse patches of woodland and desertscrub vegetation, and potential cavity-harboring substrates.

RESUMEN.—Se describen el tamaño y composición de cuatro áreas ocupadas por machos ($N = 3$) y una pareja de la especie en peligro, buho pigmeo de los cactáceas (*Glaucidium brasilianum cactorum*) en el valle de Altar en el sureste de Arizona durante 1999. En estas áreas, se compararon los árboles, sitios, y áreas de perchado llamado ($N = 27, 18$, y 13) contra sitios al azar. Las áreas usadas (polígono mínimo convexo) midieron de 9.9–47.3 ha y incluyeron las comunidades de bosque, matorral desierto, sabana, y pastizales. El uso de la comunidad boscosa, excedieron disponibilidad, y en las comunidades de sabana y pastizal el uso fue menor a lo disponible. Los árboles de percha y llamado presentaron mayor altura ($P < 0.001$), diámetro basal ($P < 0.001$), y diámetro de copa ($P = 0.003$), que los substratos disponibles. Los sitios de perchado (0.003 ha) fueron mas altos en la riqueza de plantas, volumen total de vegetación y el volumen de la vegetación >2 m sobre el suelo que los sitios al azar ($P \leq 0.035$). La altura, el diámetro basal, la distancia de las plantas vecinas mas cercanas ≥ 3 m de altura, y la distancia del perchado al cauce del drenaje mas cercanas, distinguen mejor los sitios de perchado llamado de los sitios aleatorios. La retención de árboles grandes, parches boscosos y matorral desierto estructuralmente diversa, y los substratos con potencial para contener cavidad pueden ayudar en los esfuerzos de recuperación y manejo para esta especie en Arizona.

[Traducción de Gabriel Valencia Ortega]

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INTERSPECIFIC AND INTRASPECIFIC KLEPTOPARASITIC INTERACTIONS OF THE BEARDED VULTURE (*GYPÆTUS BARBATUS*) AT NESTING AREAS

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KEY WORDS: *Bearded Vulture*, *Gypaetus barbatus*; *interspecific interactions*; *intraspecific interactions*; *kleptoparasitism*; *nesting areas*.

Kleptoparasitism is the stealing of previously procured food from heterospecifics or conspecifics (Brockmann and Barnard 1979). This behavior is quite widespread among birds, especially among seabirds (Furness 1987). Although kleptoparasitic interactions in vultures have been reported in the literature (Brockmann and Barnard 1979, Pascual and Santiago 1991, Bertran and Margalida 1996, Margalida and Heredia 2002) information on this behavior at nesting areas is scarce. This may be due to the fact that vulture species generally interact around the carcass (Álvarez et al. 1976, König 1983, Blanco et al. 1997, Mundy et al. 1992) and that they deliver food, which they carry in their crop to the nest, making theft of this food by other birds difficult.

The Bearded Vulture (*Gypaetus barbatus*) is a solitary and territorial osteophagous vulture that inhabits mountain areas of the southern Palearctic and the Afrotropical region (del Hoyo et al. 1994). In contrast to the ecology of other vultures, this species presents some features that may favor kleptoparasitism: (1) the carrying of large bones or bone fragments that are visible to other species, (2) the repeated breaking actions that take place in the ossuaries, and (3) the predictability of food sources where prey items accumulate (ossuaries, perches, and nests). Nevertheless, kleptoparasitic events involving the Bearded Vulture have only been reported occasionally (Elosegi 1989).

In the eastern Pyrenees, the Bearded Vulture population occurs in a high population density (Margalida et al. 2003) and with an abundant food supply (Margalida et al. 1997). These factors suggest a low frequency of kleptoparasitism events because this feeding strategy is favored when food is less abundant (Stillman et al. 1997). On the other hand, a low frequency of interspecific interactions would be expected as consequence of low benefits that could be obtained by heterospecifics from stealing a specialized food such as bone remains.

In this note, we document some interspecific and intraspecific kleptoparasitic interactions of the Bearded Vulture at nesting areas and we analyze the factors affecting this behavior.

MATERIAL AND METHODS

Fieldwork was undertaken between 1991–97 in the central Pyrenees (Catalonia, northeast Spain) during a larger study of the breeding biology of this species (Margalida and Bertran 2000). Eight focal pairs were studied and we recorded incidental observations of another seven pairs during the pre-laying, incubation, and chick-rearing periods (September–July).

Bearded Vulture nests are situated on rocky cliffs at altitudes between 650 m and 2100 m. Among the species which coexist with the Bearded Vulture and which often interact with it are the Golden Eagle (*Aquila chrysaetos*) (10 territories), the Egyptian Vulture (*Neophron percnopterus*) (four territories), the Common Raven (*Corvus corax*) (14 territories), and the Eurasian Griffon (*Gyps fulvus*) (nine territories). At the same time, there are also intraspecific interactions with individuals of various age classes (immatures, <3 yr; subadults 4–5 yr; adults >6 yr) that often visit the nesting areas.

Observations were made using 20–60× telescopes from vantage points that allowed a good view of nesting sites

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Table 1. Inter- and intraspecific kleptoparasitic actions of Bearded Vultures observed in nesting areas in Spain.

KLEPTOPARASITE	HOST	
	BEARDED VULTURE (ADULT)	GOLDEN EAGLE
Bearded Vulture (immature)	19	0
Bearded Vulture (subadult)	2	0
Bearded Vulture (adult)	1	1
Golden Eagle	2	0
Griffon Vulture	13	0
Common Raven	16	0

(300–600 m). Notes were made of all interactions in which food was stolen, the species involved, and the situation in which they occurred (in flight, on the nest, at an ossuary, or on a perch). In all intraspecific interactions observed, we recorded the individual’s age, which was determined following Bertran and Margalida (1996).

RESULTS

We observed 54 interactions consisting of food theft, 26 of which took place at ossuaries, 24 at the nest, 3 in flight, and 1 on a perch. Twenty-two of all interactions were intraspecific, while the remaining 32 were interspecific. No significant difference was observed among the situations where the two types of interactions took place ($\chi^2_2 = 1.5$, $P = 0.47$). In 96.3% of all interactions Bearded Vulture adults acted as hosts and only in two did they act as kleptoparasite (Table 1).

Intraspecific Interactions. Thirteen of all intraspecific thefts took place at the ossuaries, eight at the nest, and only one in flight. The frequency of thefts observed was higher than expected in places where prey remains accumulated, such as nests or ossuaries. Direct kleptoparasitic actions in flight were avoided ($\chi^2_1 = 9.28$, $P < 0.001$). Twenty-one actions (95.5%) were carried out by non-breeding individuals. Birds that were less than 3 yr old took part in 19 of all actions and this age group used this feeding strategy more often than expected ($\chi^2_2 = 13.01$, $P < 0.001$). The only kleptoparasitic action in flight took place between two adult birds in a territory held by a polyandrous quartet. The parasitic individual followed insistently a bird that was carrying the bone remains, flapping its wings vigorously. After an aerial chase of 15 min, the adult bird that was carrying the remains dropped its prey, which the other adult bird collected on the ground.

Interspecific Interactions. Of 32 interspecific interactions observed in which food was stolen, in only one case was the Bearded Vulture the kleptoparasitic species: the vulture robbed a Golden Eagle of the prey it was holding in its talons while perched in the vicinity of its nest. Once in flight, the eagle chased the vulture and tried to recov-

er the prey, which fell into a wooded area from which it could not be recovered. In the remaining 31 interactions, the Bearded Vulture acted as host. In flight it was kleptoparasitised only twice, both by Golden Eagles which chased and took from the vultures’ talons the prey they were carrying. On one of these occasions, the prey was dropped and the eagle retrieved it before it touched the ground. Of the other 29 occasions, the Bearded Vulture suffered 16 of the thefts at the nest by ravens and 13 of the thefts at ossuaries by Eurasian Griffons. As occurred with intraspecific interactions, interspecific events of kleptoparasitism mostly occurred in those places where food was accumulated/gathered, with kleptoparasitic chases in flight being significantly infrequent ($\chi^2_1 = 12.44$, $P < 0.001$).

DISCUSSION

Our results suggest that the non-breeding population of Bearded Vultures, perhaps due to limited foraging efficiency (Brown 1988, Bertran and Margalida 1996), as has been suggested with other species (Fisher 1985, Caldw et al. 1999), are making use of the spatial and temporal predictability of food resources by becoming kleptoparasites. All thefts suffered at the nest by breeding pairs of Bearded Vulture took place during chick-rearing, a period when prey items often accumulate at the nest sites. Theft at ossuaries or in flight occurred during winter (pre-laying and incubation periods), a time when food availability is reduced and weather may greatly limit the activities of foraging and locating food. For those age groups (principally <3 yr) that are more dependent on predictable food sources such as feeding stations (Hereidia 1991), this might be a foraging strategy used much more regularly. These results are in agreement with the idea that immature or inexperienced birds may compensate for their less-effective foraging abilities by kleptoparasitism (Wunderle 1991). To the contrary, kleptoparasitism by adults could be an opportunistic foraging behavior. Nevertheless, our observations were mainly done close to the nest and do not include observations during foraging. This accounts for the fact that breeding adults were the host bird in 96% of all observed events. Nevertheless, the abundant food available and the relatively infrequent number of stolen prey, suggest that kleptoparasitism amounts to a small cost for the breeding pairs, without any measurable impact on breeding success (see Margalida et al. 2003).

As a result of the cost/benefit rate, two factors would determine that the species that attempted stealing would resort to this indirect strategy: the territorial behavior of the Bearded Vulture (Margalida and Bertran 2000, Bertran and Margalida 2002) and the accumulation of prey remains in nesting areas. Dominance of adults over immatures is a well documented phenomenon in raptors (Newton 1979), but a reverse-dominance pattern also has been observed (Rodríguez-Estrella and Rivera-Rodríguez 1992). In the case of conspecifics, plumage coloration of

Bearded Vulture adults could act as status signal (Negro et al. 1999). This signal could be used by territorial adults to displace other immature Bearded Vultures not by attacking them, but simply by signalling their status while approaching them (Bautista et al. 1998). On the other hand, the Bearded Vulture's low wing loading and its large wingspan give this species great dominance in flight (Donazar 1993) and make it difficult for an opponent to steal food successfully. In the case of conspecifics, the fact that younger birds are less skillful in flight would mean that they would be less successful in actions of direct piracy, so that the energetic cost of those attempts might be greater than the likely benefits obtained from those actions (Fisher 1985).

Concerning the interspecific interactions, the prey remains consumed by Bearded Vultures mostly consisting of bone remains, would be energetically inadequate for many raptor species (e.g., Golden Eagles). In the case of Eurasian Griffons, they would be occasionally more interested in obtaining bone remains at ossuaries (Bertran and Margalida 1997) in order to compensate for a possible lack of calcium in their diet (Mundy and Ledger 1976). The dominance of the Eurasian Griffon on the ground, given its larger size and the accumulation of bone fragments and splinters at ossuaries, would favor the strategy of obtaining calcium at these sites (Bertran and Margalida 1997). Furthermore, the Bearded Vulture's attacks of intruders in the vicinity of the nest throughout the breeding season (Brown 1988, Margalida and Bertran 2000) would act as deterrent and would make food storages near the nest the least convenient for stealing. The success in aggressive encounters appears determined by the body size and condition, and the previous possession of the disputed resource (Bautista et al. 1998). In contrast, those species with higher aerial maneuverability but with smaller size, such as ravens, would have to focus their actions at the nest, where prey remains also accumulate. Obtaining prey remains there may be less costly for those birds because: (1) adults are gradually less often present at the nest as the breeding season progresses (Brown 1990, Margalida and Bertran 2000) and (2) prey items present in the nest have a higher meat content as consequence of differential requirements in nutrients for the chick (Margalida and Bertran 1997, Margalida and Bertran 2001).

Finally, kleptoparasitism could be a strategy of demonstrating dominance or competence (Bautista et al. 1998). The fact that in our study area the Bearded Vulture density is high (Margalida et al. 2003), heterospecifics compete by the same nest sites (Margalida and García 1999), and food supply is abundant, suggest that kleptoparasitic actions could be determined by other resources than food. For example, demonstrating dominance or competence by nest sites or in breeding territories may result in social benefits (Caldow et al. 1999, Yates et al. 2000).

RESUMEN.—Documentamos interacciones interespecíficas e intraspecíficas de cleptoparasitismo en el quebrantahuesos en los sectores de nidificación. De un total de 54 interacciones, 26 tuvieron lugar en rompederos, 24 en el nido, tres en vuelo y uno en posaderos. Veintidós de las interacciones fueron intraspecíficas y las 32 restantes interespecíficas con cuervos (*Corvus corax*), buitres leonados (*Gyps fulvus*) y águilas reales (*Aquila chrysaetos*). La mayoría de las interacciones tuvieron lugar en zonas donde el alimento se acumulaba (nidos y rompederos) evitando las acciones directas en vuelo. En el caso de los adultos, este comportamiento podría ser una acción oportunista pero para las aves de <3 años sí podría tratarse de una estrategia alimenticia. Puesto que la disponibilidad trófica es suficiente, la población reproductora está incrementándose y las especies heterospecíficas compiten por los mismos sectores de nidificación, el cleptoparasitismo podría estar relacionado con otros factores no relacionados con la obtención de alimento.

[Traducción de los autores]

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GYRFALCON PREDATION ON MALLARDS AND THE INTERACTION OF BALD EAGLES WINTERING IN CENTRAL ALBERTA

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KEY WORDS: *Gyr Falcon*; *Falco rusticolus*; *Bald Eagle*; *Haliaeetus leucocephalus*; *Mallard*; *Anas platyrhynchos*; *foraging success*; *kleptoparasitism*; *predation*.

The food habits of Gyrfalcons (*Falco rusticolus*) have been studied mainly by the collection and identification of prey remains (Palmer 1988, Poole and Boag 1988, Cade et al. 1998). Field observations of Gyrfalcons capturing prey are few and anecdotal (White and Weeden 1966, Bengtson 1971, Dobler 1989, Garber et al. 1993). The largest data sets of hunts and kills by wintering Gyrfalcons originate from urban study areas. Jennings (1972) and Dekker and Lange (2001), respectively, detailed the capture of 17 Mallards (*Anas platyrhynchos*) and 15 Rock Doves (*Columba livia*) in Stockholm and Edmonton. We present a comparable sample of Mallard kills by Gyrfalcons wintering in a rural region of Alberta. Bald Eagles (*Haliaeetus leucocephalus*) usually forage over water, and their kleptoparasitic habits are well known, particularly at the expense of the Peregrine Falcon (*Falco peregrinus*) (Anderson and DeBruyn 1979, Dekker 1987, 1995). In this paper, additionally, we describe observations of eagles hunting ducks over land and pirating prey from Gyrfalcons.

STUDY AREA AND METHODS

The latitude of the study area is 53°N and the climate is cold continental. The North Saskatchewan River, that flows through Edmonton, Alberta, is frozen from November to May except for a stretch of roughly 10 km downstream from the city. The open water attracts 1000–2000 Mallards that stay all winter. In fall, they make daily feeding flights of 2–10 km over gently undulating agricultural plains. After the ground is covered with >10 cm of snow, the ducks abandon the stubble fields and congregate at farms where cattle are being fed with grains or silage. Gyrfalcons are migrants and winter residents in central Alberta. Earliest and latest records are 25 September and 14 April, although the majority of sightings date from November to mid March (Dekker 1983, Court 1999). Bald Eagles winter in south-central Alberta where lakes or rivers remain ice free (Godfrey 1986).

To study the interaction between ducks and Gyrfalcons we used three principal methods. (1) Sitting in a parked vehicle, we monitored feeding ducks for sudden alarm behavior caused by the arrival of a predator. (2) From a vantage point overlooking the river valley, we frequently scanned the skies through binoculars, waiting for the Mallards to leave the river. (3) Gyrfalcons, either flying or perched, were observed in anticipation that they may initiate the pursuit of prey. Over three winters, 1999–2002, we visited the study area on 95 days (3–5 hr/d) and sighted one or more Gyrfalcons on 56 days.

A “hunt” was defined as an attempt by a Gyr Falcon at capturing a duck of which the outcome was known (Dekker 1980). The term “kill” indicates that we saw the Gyr Falcon pursue and seize a duck, or that we located the falcon on its prey shortly after the hunt. A “probable kill” indicates that a Gyr Falcon, in close pursuit of a duck, chased it down to the ground and disappeared from view behind trees or sloping terrain in the distance. Additional clues were provided by Bald Eagles that flew to and descended in the same locality of the suspected Gyr Falcon kill.

RESULTS AND DISCUSSION

Gyrfalcons. During each winter, 1999–2002, we sighted four to seven different Gyrfalcons, ranging from very dark immatures to partly white adults (Court 1999, Dekker and Lange 2001). Some recognizable individuals stayed in the study area for a period of several days or weeks; others were sighted only once.

Gyrfalcons are known to hunt low over the ground and seize avian prey just after it flushes. The target prey may be first spotted from an elevated perch (White and Weeden 1966, Bengtson 1971, Palmer 1988, Clum and Cade 1994). A similar strategy of surprise was employed by the Gyrfalcons in this study. Their sudden arrival, flying low over the ground, caused the ducks to fly up. After selecting an individual duck, the Gyr Falcon chased it on an erratic, twisting course. If the hunt failed, the falcon perched on a post or tree and then launched another hunt. We saw a total of 42 low surprise hunts of which five resulted in a kill (Table 1). In four additional instances, we just missed seeing the attack and discovered the falcon on a fresh kill. Six successful low-surprise hunts

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Table 1. Hunting methods of Gyrfalcons preying on Mallards in Alberta, Canada.

HUNTING METHOD	HUNTS	KILLS	PROB- ABLE KILLS
Stealth attack on feeding ducks	42	5	—
High, open attack on flying ducks	25	10	3
Unknown approach	3	1	1
Totals	70	16	4

were reported to us by the associate observers listed in the Acknowledgments.

A very different strategy was employed by Gyrfalcons that flew out to meet airborne ducks at altitudes of 50–300 m and still >2 km away. Leaving a perch, the Gyrfalcon began a long climb, gradually increasing speed. At the falcon’s approach, the ducks turned away and split up. In the terminal stage of the hunt, the Gyrfalcon selected a single duck that appeared to realize its vulnerability and descended in an attempt to reach cover. Twenty-five of these open hunts resulted in 10 confirmed and three probable kills (Table 1).

Most pursuits ended in a close tail-chase. In the two exceptions, the Gyrfalcon flew 20–100 m higher than the duck and stooped at it nearly vertically. In both cases, the duck dodged the stoop and landed, followed by the falcon. One was a confirmed kill, the other a probable kill. We saw no evidence that the falcons struck and knocked down their prey. In all observed captures, the falcon seized its prey in mid-air or on the ground.

The majority (77%) of ducks that were closely pursued escaped into low vegetation protruding from the snow, or into bushes or roadside trees. In two instances, the falcon landed on the road shoulder and, in a futile attempt to flush the duck, walked into the snow-drifted ditch under the trees. Eight ducks landed on the weedy shoulders or medians (10–15 m wide) of divided highways, and two of these ducks were seized by the falcon while heavy traffic passed by. In other cases, the falcon repeatedly swooped at the duck but failed to grab it. One drake, observed at close range, defended itself by lunging with gaping bill at the swooping raptor. After several failed passes, the Gyrfalcon perched in the vicinity. When the drake took off, it was immediately pursued until it again took cover. E. Pletz saw a Gyrfalcon pursue a duck until it went down on an open, snow-covered field. The falcon swooped at the duck, but did not seize it and landed 1–2 m away. Such stand-offs between Gyrfalcons and Mallards have been described by others (Jenning 1972). Gyrfalcons can be similarly reluctant to grab tethered decoy pigeons that refuse to flush (Dekker and Lange 2001, E. Pletz pers. comm.).

A true assessment of the hunting success rate of the Gyrfalcons in this study is difficult. Based on confirmed

kills, the success rate was 22.9%. The addition of probable kills brings the rate up to 28.6%. This is more than twice as high as the 10.6% success rate in 141 hunts by Gyrfalcons preying on Rock Doves (Dekker and Lange 2001). Mallards are less maneuverable than pigeons and usually escape from falcons by plunging into water. In this study, the Gyrfalcons outflow and forced down any Mallard they pursued with persistence. Although the long-range, high altitude interception of flocks of ducks by Gyrfalcons has not been described in the literature, similar direct-climbing attacks on other avian prey have been reported and the Gyrfalcon’s capacity in this regard is well-known to falconers (Cade 1982). An identical mode of hunting, launched from a perch and aimed at the interception of high-flying ducks, was employed by male peregrines (*F. p. pealei*) wintering in British Columbia (Dekker 1995, 1999).

Although some Gyrfalcons observed in the study area were seen hunting Rock Doves or found feeding on Gray Partridges (*Perdix perdix*), their primary prey appeared to be the (locally-wintering) Mallards. Probably in response to predation risk, the ducks delayed their feeding flights. During fall, the flocks routinely traveled to the stubble fields near noon. However, after they had been attacked often, they might not leave the river until close to sundown. For instance, on 18 February 2002 the first flock (20–25 ducks) left the river at 1500 H. As soon as they detected an approaching Gyrfalcon, the flock turned back and escaped into water. The falcon remained in the area, often switching perches. Two hours later, the ducks suddenly left the river again in multiple flocks totalling hundreds of birds. At the approach of the Gyrfalcon, only the flock under direct attack returned to the river, pursued by the falcon, while other flocks continued on to a feeding area about 8 km away.

Of nine Mallard kills of which the sex was known, seven were drakes and two hens. In two instances, a Gyrfalcon ate only part of a drake and returned to the remains the following morning. Two other falcons consumed all flesh from the carcass in 35–45 min, leaving only the head, the pelvis, and the lower portion of the legs. As reported by a farmer who shot a number of raiding Mallards, by late winter these ducks were emaciated.

Bald Eagles. During the freeze-up period, the last of the Bald Eagles migrating through central Alberta actively hunt ducks in water holes of lakes (Dekker 1984). However, the food habits of the Bald Eagles wintering in the study area have not been studied in detail. Each year, we counted three to six eagles perched on trees along the open stretch of the river. One eagle was seen to catch a Mallard in the river. In late fall, the eagles also perched on trees overlooking the stubble fields where Mallards congregated. Some eagles actively hunted the ducks in fast, low-surprise attacks. However, all of 12 chases of ducks that flushed just ahead of eagles were unsuccessful. One immature eagle pounced on a drake that had turned back and landed again 20–25 m away. Associate

observers reported three additional captures of Mallards of which one was taken in flight (F. Whiley).

After the fields were covered in snow and the ducks commuted daily to cattle feedlots, the eagles left the river and perched on trees in view of the feeding ducks. We suspect that they were also watching for opportunities to steal prey from other raptors. We never saw Gyrfalcons attack ducks on farms, where eagles sat waiting on prominent perches. However, if falcons hunted in the distance, it was common to see eagles fly toward that direction, apparently searching the fields. We saw four eagles rob Gyrfalcons, which released their ducks at once. Two additional cases of kleptoparasitism were reported by associates (E. Pletz, F. Whiley). The Gyrfalcons did not defend their prey against the eagles. Other raptors seen to hunt the ducks were Northern Goshawks (*Accipiter gentilis*) (six low attacks), Prairie Falcon (*Falco mexicanus*) (one flush and long chase), and Snowy Owls (*Nyctea scandiaca*) (two low attacks). After watching a Gyrfalcon feed on its kill, one Snowy Owl scavenged the remains.

Note added in proof: During February and March of 2003, we saw 35 hunts (24 stealth and 11 open attacks), resulting in three probable and four confirmed kills. Additionally, the falcons seized two ducks, on or near the ground, which were released again moments later. Three confirmed kills were pirated by Bald Eagles. All of five known falcon kills were hen Mallards.

RESUMEN.—Patos de la especie *Anas platyrhynchos* que migraron a un estrecho no congelado río abajo de la ciudad de Edmonton, Alberta, intercambiaron diariamente los campos de siembra y las áreas de forraje de ganado, donde fueron atacados por halcones gerifaltes (*Falco rusticolus*). Setenta intentos de caza dieron lugar a 16 muertes confirmadas y cuatro probables. La mayoría (77%) de los patos perseguidos por los halcones escaparon a la captura, cubriéndose en el suelo, en arbustos, o a lo largo de los bordes de la carretera. Las presas fueron atrapadas en tierra o en aire. Los gerifaltes utilizaron dos métodos principales de caza: (1) ataques bajos por sorpresa contra patos que se alimentaban; (2) intercepciones de largo alcance de patos en vuelo alto. Las tasas de éxito para estos métodos de caza fueron 12% y 40%, respectivamente. Las águilas calvas (*Haliaeetus leucocephalus*) persiguieron a los patos sobre campos de cultivo, teniendo un éxito relativo. Adicionalmente, se apoderaron de patos que habían sido capturados por los halcones.

[Traducción de César Márquez]

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WINTERING SNOWY OWLS FEED ON SEA DUCKS IN THE BELCHER ISLANDS, NUNAVUT, CANADA

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KEY WORDS: *Snowy Owl*; *Nyctea scandiaca*; diet; polynyas; sea ducks; wintering.

Snowy Owls (*Nyctea scandiaca*) have a broad wintering distribution that covers much of Canada and northern United States (Kerlinger et al. 1985). The owls consistently winter in the northern Great Plains while their movements to the east and west are more irruptive consisting mostly of immature birds (Kerlinger and Lein 1986). Snowy owls have a varied diet of mammals and birds, but usually focus on lemmings (*Lemmus* spp. and *Dicrostonyx* spp.) during the breeding season and other small rodents and birds that are abundant during the non-breeding season (Watson 1957, Boxall and Lein 1982a, Parmelee 1992).

Most research on wintering Snowy Owls has been conducted in the Canadian Prairies (Boxall and Lein 1982a, 1982b, Kerlinger and Lein 1988a, 1988b), but there have been relatively few studies of Snowy Owls wintering further north. The Belcher Islands, Nunavut, Canada (56°00'–57°30'N, 79°30'–80°00'W) are known breeding and wintering areas for Snowy Owls (Todd 1963, Freeman 1970, Manning 1976). While studying the ecology of sea ducks wintering around the Belcher Islands, we also recorded Snowy Owls (Gilchrist and Robertson 2000). Herein, we expand on our observations of Snowy Owls, describing their distribution and their relationship with wintering Common Eiders (*Somateria mollissima*) and Long-tailed Ducks (*Clangula hyemalis*).

METHODS

Field work was conducted during three separate 3–4 wk periods during the winters of 1998 and 1999 (March 1998, January 1999, March 1999) on the Belcher Islands, southeastern Hudson Bay. Throughout the winter, areas of near-shore, open water are present in the Belcher Islands archipelago. These open-water areas are of two types: (1) small recurring polynyas in areas of strong tidal currents, and (2) water that is adjacent to ice-floe edges and remains free of ice only during offshore winds (Nakashima and Murray 1988, Gilchrist and Robertson 2000).

During each winter, we traveled by snowmobile, with

local Inuit guides, to various open-water areas around the Belcher Islands (Gilchrist and Robertson 2000). Destinations depended mainly on past and present weather conditions, and on information from other Sanikiluaq hunters who reported locations of recent sea duck sightings.

After arriving at each area of open water, we estimated how many individuals of each species were present. If ducks were sighted and were reasonably close to the ice edge (<500 m), we remained at the same site to collect behavioral data and information on the population of birds using the site; otherwise, we moved on to another open-water area. If conditions were suitable at the end of observations, our guides attempted to collect sea ducks. We did not always see Snowy Owls immediately upon arrival as we inspected surrounding ice ridges with spotting scopes or binoculars after observations of sea ducks were completed. Sometimes we saw owls after they flew; therefore, we believe our sightings underestimate the actual number of Snowy Owls present.

Snowy Owl numbers at water bodies were best described by a Poisson distribution (coefficient of dispersion = 1.63), so we used Poisson regressions to examine relationships between duck and Snowy Owl numbers. The data were observational, so we conducted the analysis using a model-selection framework (Burnham and Anderson 1998) rather than a traditional hypothesis-testing framework. In the model-selection framework, candidate models are constructed, and their ability to fit the data, without including too many parameters, is evaluated using Akaike's Information Criterion (AIC). To explain the number of Snowy Owls sighted, we constructed four candidate models. The first model included terms for numbers of Common Eiders and Long-tailed Ducks present, the second only eiders, the third only Long-tailed Ducks, and the last included only an intercept term. As some observations were from the same water body, we included the location of sightings as a repeated measure in the Poisson regression, and used a corrected AIC (termed AIC_C) that used number of locations rather than number of sightings. Medians, means, and ranges are also presented to describe the data (see Gilchrist and Robertson 2000).

RESULTS AND DISCUSSION

Snowy Owls were regularly seen at several open-water areas. On 56 trips to 14 different water bodies, Snowy Owls were seen 15 times. The observed number of Snowy

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Table 1. Model fitting results of Poisson regressions, with numbers of ducks as the predictor(s) and number of Snowy Owls as the response. Models with the lowest AIC_c values indicate the most parsimonious (i.e., best fitting) model. K is the number of parameters, while Deviance is a measure of model fit.

MODEL	K	DEVIANCE	AIC _c
Common Eiders +			
Long-tailed Ducks	3	62.78	71.18
Common Eider	2	68.06	73.15
Long-tailed Duck	2	69.91	75.00
Intercept only	1	84.31	86.65

Owls ($\bar{x} = 0.4$, range 0–1) was positively related to the observed number of Common Eiders ($\bar{x} = 1169$, range = 0–12 500) and to the observed number of Long-tailed Ducks ($\bar{x} = 55$, range = 0–700) (Table 1).

On two different occasions we saw a Snowy Owl take a carcass of a Long-tailed Duck directly off the water immediately after the duck was shot by our Inuit guides. On another occasion, when our guides shot a male Common Eider, a Snowy Owl made a few passes over the carcass but did not come close enough to seize it, presumably because we were standing directly at the floe edge trying to retrieve the eider. Our Inuit guides described additional instances where they observed owls taking crippled eiders off the water (Nakashima and Murray 1988). In all cases, the owls appeared from the ice-edge and flew out over the water. Owls often perched on ice ridges piled up at the landfast ice-edge, and appeared to watch sea ducks from there. Owl pellets and what appeared to be raptor-killed carcasses (only breast bone and wings remaining) of both eiders and Long-tailed Ducks were also found at ice perches along the floe edge. To our knowledge, there are no other raptors wintering in the Belcher Islands (Gilchrist and Robertson 2000), although some of these remains may have been left by scavenging Arctic foxes (*Alopex lagopus*) and Common Ravens (*Corvus corax*).

We were able to travel continuously along two of the floe edges. The first was ca. 10 km long, and we saw four owls; the second was ca. 15 km long, and we saw three owls. The owls appeared to be spaced out evenly along these flow edges, at approximately 2–5 km intervals. Snowy Owls wintering in the Prairie Region of Canada form winter territories (Boxall and Lein 1982b), as do Snowy Owls wintering in Massachusetts (D. Holt pers. comm.). It is therefore possible that Snowy Owls form temporary territories along the floe edges that have open water.

Snowy Owls apparently associate with concentrations of Common Eiders and Long-tailed Ducks. Eiders spend considerable time loafing and resting on the ice, especially at night or when currents are strong. Out of water,

eiders may be particularly vulnerable to Snowy Owls and other predators, such as Arctic fox, as they cannot dive to escape (Nakashima and Murray 1988). While Long-tailed Ducks (700–800 g) may be easier prey for Snowy Owls, Common Eiders may be a more important source of food because they are larger (>2000 g) and more abundant in the Belcher Islands. Also, large numbers of Common Eiders (100s–1000s) occasionally starve when open-water areas freeze over (Nakashima and Murray 1988, Gilchrist and Robertson 2000), making the eiders easy prey.

Although Snowy Owls are known to prey primarily on small mammals, they will consume waterbirds when that prey is plentiful. On the coast of southwestern British Columbia, wintering Snowy Owls consumed a wide variety of waterbirds, with Horned Grebes (*Podiceps auritus*) being the most common prey item, followed by Bufflehead (*Bucephala albeola*) (Campbell and MacColl 1978). Although Campbell and MacColl (1978) demonstrated that birds in 400–800 g weight class were preferred, birds as large as White-winged Scoters (*Melanitta fusca*) at 1300 g, Mallards (*Anas platyrhynchos*) at 1100 g, and Glaucous-winged Gulls (*Larus glaucescens*) at 1200 g, were also present in the diet. In Alaska, non-breeding Snowy Owls consumed many Ancient Murrelets (*Synthliboramphus antiquus*), as well as other alcids and ducks (Williams and Frank 1979). Snowy Owls migrating along the St. Lawrence River fed heavily on murrets (*Uria* spp.) (Bent 1938). Portenko (1989) describes that Snowy Owls wintering on St. Lawrence Island, Bering Sea, fed exclusively on wintering ducks, specifically Long-tailed Ducks and King Eiders (*Somateria spectabilis*). Snowy Owls wintering in the Belcher Islands also appear to focus their winter foraging in marine areas where sea ducks are plentiful.

We suggest that Snowy Owls are important members of the avian community wintering in the Belcher Islands. Our observations show that Snowy Owls prey upon abundant wintering sea duck populations and that their distribution and abundance within the region are positively associated with concentrations of sea ducks. Sea ducks have to move around the Belcher Islands archipelago as open-water areas change locations with varying currents and winds. Snowy Owls likely move with the sea ducks, following them around the archipelago and possibly establishing temporary territories. As with the Great Plains of North America (Kerlinger and Lein 1986), the Belcher Islands, and perhaps other areas in the Arctic with recurring open-water bodies and wintering sea ducks, are likely used consistently by Snowy Owls (Portenko 1989).

RESUMEN.—Documentamos la presencia del búho nival (*Nyctea scandiaca*) durante la migración de otoño en las Islas Belcher, Nunavut en 1998–99. En 56 viajes a los sitios de estudio, algunos búhos fueron relacionados con *Somateria mollissima* y con *Clangula hyemalis* presentes en los cuerpos de agua abiertos. Lo búhos fueron observados, capturando en el agua a los patos de cola larga he-

ridos. También fueron detectados en perchas de filos de hielo con restos de patos o con egragopilas cercanas. Las áreas de aguas abiertas de las Islas Belcher y las de las "polynias" recurrentes, así como los bordes de los témpanos de hielo, pueden ser utilizados consistentemente como áreas de destino de la migración de otoño, por el búho nival.

[Traducción de César Márquez]

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THE COLONIZATION OF SICILY BY THE BLACK KITE (*MILVUS MIGRANS*)MAURIZIO SARÀ¹*Department of Animal Biology, University of Palermo, 18 via Archirafi, 90123, Palermo, Italy*

KEY WORDS: *Black Kite*, *Milvus migrans*; *Red Kite*, *Milvus milvus*; *colonization*; *Sicily*.

The Black Kite (*Milvus migrans*) is a locally common and widespread migratory breeder throughout the Palearctic (Bijlsma 1997). This species was much more abundant in the recent past and it has been classified as vulnerable within Europe (Viñuela and Sunyer 1994). In Italy, the species' stronghold is located in the lake district of the Italian Alps, where eight of nine populations surveyed in the 1990s were found to be declining (Sergio and Boto 1999, Sergio et al. 2002).

MATERIALS AND METHODS

The Sicani Mountain, in central Sicily, is an area of ca. 1500 km², where the raptor population has been continuously monitored for the last 30 years. The raptor surveys have included both the wintering population, by road census, and the breeding pairs by direct observation and counts. To monitor the wintering birds of prey some 6000 km of road were surveyed by vehicle for over two decades (Massa 1980, Sarà et al. 1993, Sarà 1996a and references therein). The breeding population was monitored during the first (Massa 1985) and second Regional Atlas of breeding birds (Lo Valvo et al. 1993) and then continuously from 1999–2001.

From January 1990–August 2001, 130 excursions have been carried out to count the local population of Black and Red kites (*M. milvus*) totalling 620 hr of observation. Local ornithologists, studying other raptors in the area in 1980–2001 also provided 340 records of kite observations.

All the records on the Black Kite ($N = 86$ out of 470) were extracted from these databases and chronologically ordered to investigate the trend of population settlement. Black Kites were aged in the field following characteristics in Forsman (1999).

Several factors facilitated this analysis, namely the continuous monitoring of the area, the low densities of wintering and breeding kites, and their preferential use of some easily-monitored sites (e.g., dumps, roosts, cliffs). In addition, the review of the ornithological literature of past centuries allowed the reconstruction of the historical status of the species.

RESULTS AND DISCUSSION

Historical Status (1840–1900). The Black Kite was known in Sicily since the 19th century. The vernacular

name of this species was 'Nigghiu di passa' (migrating kite) or 'Nigghiu niuru' (black kite). Sicilian ornithologists (Benoit 1840, Minà Palumbo 1853, 1857, Doderlein 1869–74, 1893) mostly considered the species as rare and occasional. However, Maltese Schembri (1843), reported Black Kites as common in inland Sicily. Doderlein (1869–74) considered the latter report a mistake and wrote in 1869: "... indigenous in Northern Africa, very rare in Sicily; Schembri considers it as common but I think he is wrong. I have had notice of only one specimen around Palermo, which was stuffed, and I am not sure it exists in Sicily." The living and working locations of the past ornithologists, who reported the species' rarity, were distributed along the current migration route (Fig. 1) and cast very few doubts on this past status.

Recent Status (1950–2000). Today, the Black Kite is a common passage migrant along the Northern coasts of Sicily and the Messina Strait, from early March to late May. During spring, it was ranked as the second species crossing the Messina Strait in order of abundance (Dimarica and Iapichino 1984, Galea and Massa 1985, Agostini 1992). Thiollay (1977) estimated that 15 000 was the minimum number of Black Kites crossing the Mediterranean Sea, from Tunisia (Cape Bon) to Sicily. The species is more numerous on the autumnal passage, from early August to late October (Iapichino and Massa 1989). Huge concentrations of up to 1000 birds were recorded recently during late August to mid September over the Egadi Islands (Agostini et al. 2000).

The Colonization Process. Faunistic turnover is expected to occur on islands (MacArthur and Wilson 1967); but within birds, Passerines are most commonly involved (Diamond 1969, 1972, Blondel 1986). Because the past ornithological literature reported a striking difference in the Black Kite status from what occurs today, I analyzed the information related to colonization in detail.

The first confirmed breeding attempt in Sicily occurred in 1979 (Massa 1980), though earlier records of possible breeding were reported in the 1950s (Mebis 1957). Black Kites in Sicily breed on bare cliffs or, more often, on trees and big shrubs (mainly *Quercus ilex*) growing on the cliff face. Until now, only one nest is known on a tree in a woodlot, as commonly reported elsewhere in continental Europe (Sergio and Boto 1999).

During the road census completed during the winters 1977–80 (Massa 1980) the species was found to be ab-

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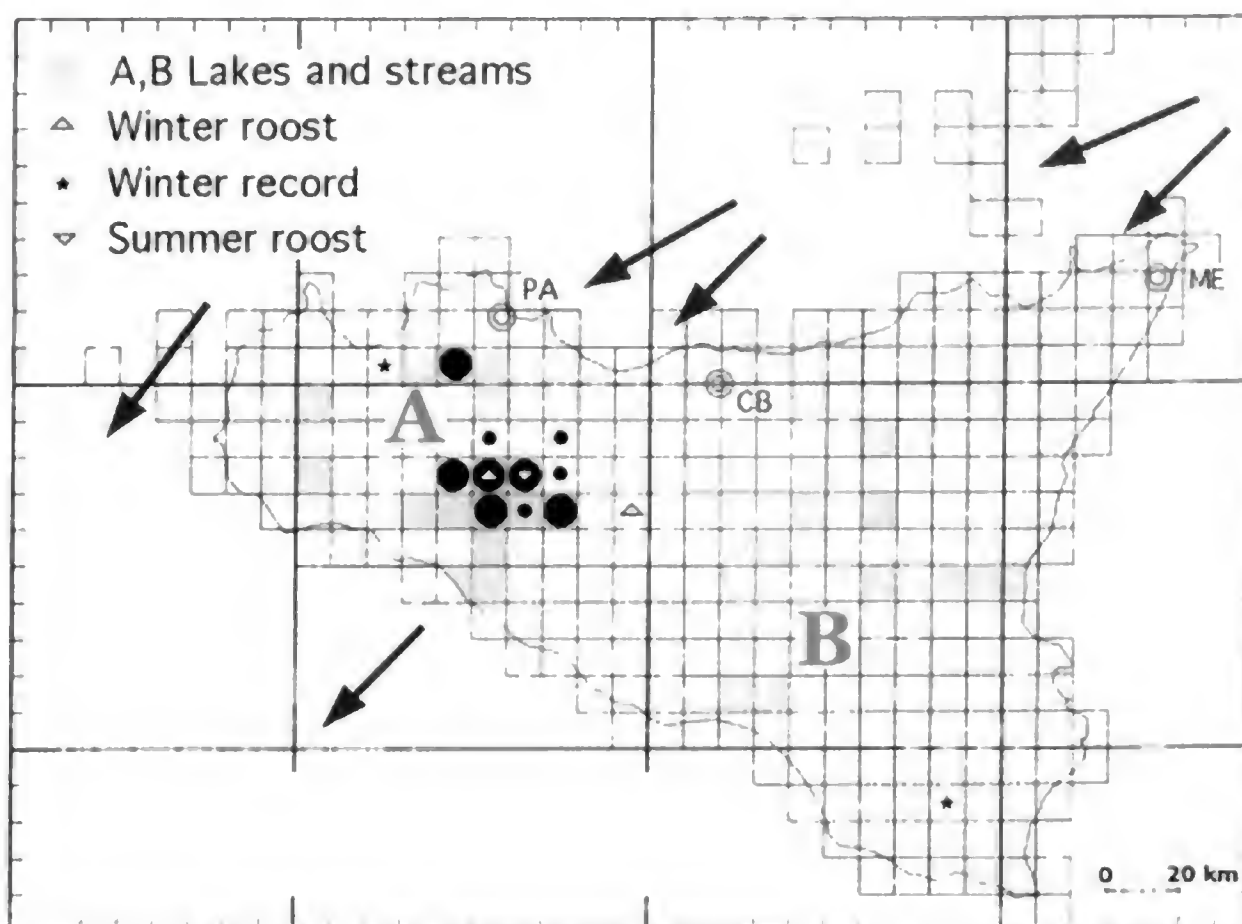


Figure 1. Map of Sicily with superimposed UTM grid of 100 km² cells, showing the main breeding and wintering area (A) of the Black Kite (*Milvus migrans*) and the other aquatic habitats potentially suitable for breeding (B). The main winter and summer roosts were in the core of the breeding range. The 2nd Regional Atlas in 1992 and 2000 recorded 10 breeding squares (large black dot = confirmed breeding; medium black dot = probable; small dot = possible). The census of 2000 showed differences in breeding status but not in the recorded number of squares. The large arrows show the main migratory routes of Black Kites over Sicily during late summer and autumn. Palermo (PA), Castelbuono (CB), and Messina (ME) are the cities where the 19th century ornithologists, who described the past species rarity, lived.

sent, but 10 yr later (1987–92), the censuses in the same area recorded a few birds overwintering regularly, with a mean of 0.3 individuals/100 km (Sarà et al. 1993). It is thus likely that, since the late 1980s, some birds formed a small group of year-long residents that, year after year, began to attract other individuals from migrating flocks in the spring.

The area of breeding and overwintering, in central Sicily, is today about 1000 km² with a core area of ca. 700 km². However, other records of this kite were reported from elsewhere on the island. The kite population is probably concentrated in the vicinity of the lacustrine and riverine system (Fig. 1; area A). The breeding area and the number of Black Kite pairs currently seem to be (1999–2001) rather stable, ca. 25–35 residents corresponding to 6–10 territorial pairs, plus a flock of 20–25 summer birds. The mean number of young fledged per successful pairs was 2.25 ± 0.96 (SE, $N = 4$), a relatively high productivity level (Sergio and Boto 1999). Systematic exploration of area B (Fig. 1) is needed to complete a survey for the species on the island.

During the winter 1990–91, one Black Kite was observed for the first time in a roost of Red Kites (*Milvus milvus*), which was located in the middle of the area A

(Fig. 1). In the following years, a small group was regularly recorded in the Red Kite roost from early September to late March (Fig. 2). The observation of juveniles of the year and second-year individuals in the winter roost was very recent (1999).

Central Sicily is a suitable habitat for Black Kites, which usually select aquatic and open habitats for foraging and for breeding (Bijlsma 1997). This area has a large number of artificial dams and large streams (Sosio, Platani, and Belice), open croplands, grazing, and some large Mediterranean mixed-oak woods. This suitable habitat lies along the migration route of the passage Black Kite flocks moving inland, and which cross the island more or less through its center en route to the southern coasts and later to pass over the Sicilian channel. I propose that after kites established this new migratory route in the early 1900s, some pairs found and began to breed in suitable habitats (Mebs 1957, Massa 1980). Initially these kites were probably present only during spring and summer; later some individuals presumably became resident and were recorded also during winter.

The last step of the colonization process was the establishment of a summer roost in a patch of pines (*Pinus pinea*) near a garbage dump (Fig. 1). Since 1998, a group

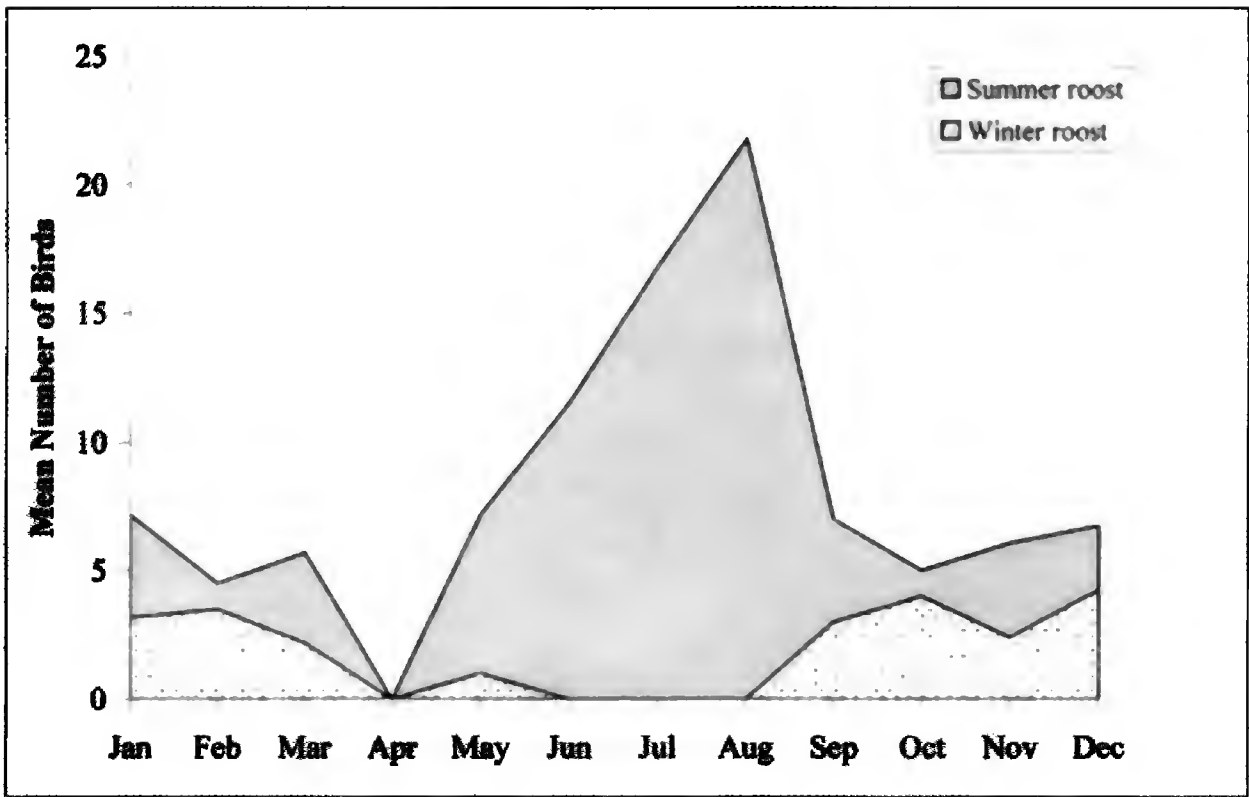


Figure 2. Mean number of Black Kites recorded in two roosts (garbage dump in summer and Red Kite roost in winter; area A, Fig. 1) in western Sicily (1992–2001).

of non-breeders arrived in late spring and settled in this roost near the dump. The number of Black Kites recorded in summer at the dump increased from a mean of 6.6 individuals to 19 non-breeding birds in 2001 (Fig. 3). In early spring, only adults were recorded. Numbers decreased to 50% in the other seasons when the second-year individuals formed half of the summer population.

Young of the year hatched in the vicinity of the roosts were observed from late August to December (Table 1). The maximum number of individuals was observed in late August, when also the residents and their young concentrated in the summer roost. From very late August to early September most of the resident population leaves the area and departures continue until early October. In

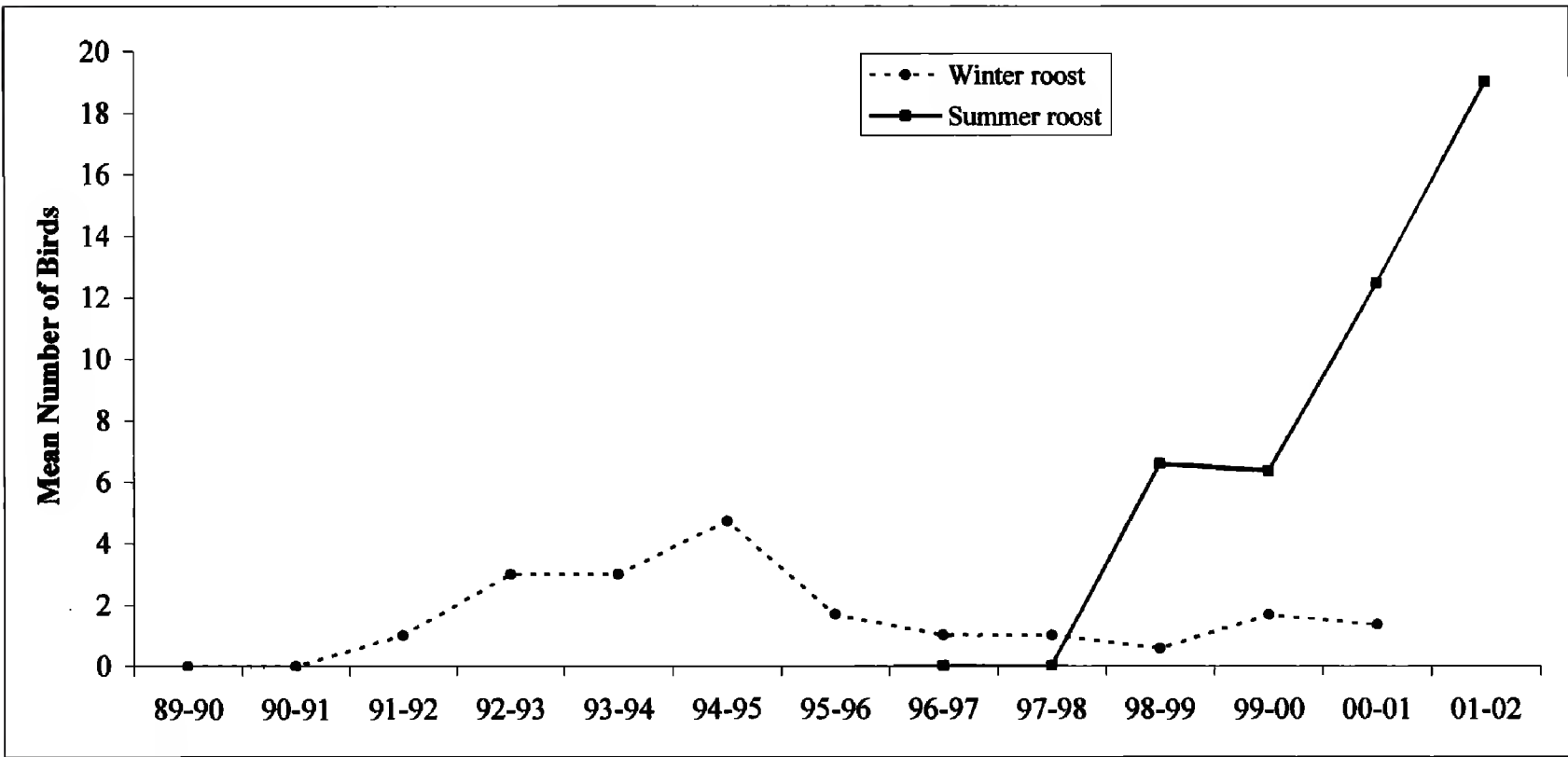


Figure 3. Mean number of Black Kites at the roosts in western Sicily (area A, Fig. 1) from November 1989–September 2001.

Table 1. Age class composition of Black Kites in western Sicily (area A, Fig. 1). Sample size is in parentheses including 74% of the total observed kites ($N = 255$) recorded during 24 visits between June 1998 and June 2001.

	NOV-FEB	MAR-MAY	JUN-JUL	AUG-OCT
Adults	0.50 (11)	1.00 (17)	0.50 (51)	0.51 (25)
Second-year birds	0.36 (8)	0.00 (0)	0.50 (50)	0.33 (16)
Young of the year	0.14 (3)	0.00 (0)	0.00 (0)	0.16 (8)

this regard, I made two direct observations (October 1994 and August 2000) of the arrival and mixing between one flock of migrating Black Kites and the group of residents in the area. In August 2000, a flock of some 120 migrating kites was recorded to arrive in late afternoon and to settle in at the roosting site that already hosted 40 residents. A visit to the roost a week later revealed the presence of only 15 birds, and that decreased to four wintering birds in November. I suggest that the dump area is a stop-over site in central Sicily for migrating kites and that its presence may have facilitated the colonization process.

It seems the first step of the colonization by Black Kites involved breeding, later followed by their presence in winter (breeders becoming residents) and finally presence in summer. This last step was probably favored by the return of birds originally bred in Sicily. Forero et al. (1999) have shown that Black Kites in Southern Spain are highly philopatric, with most of individuals coming back to breed near their natal site, but they suggested that this behaviour can vary depending on ecological conditions.

A first phase of colonization involving the presence of singles or a few birds before the onset of breeding probably occurred in the period when sporadic observations of this species were reported (Mebs 1957, Massa 1980). Thus the numerical increase recorded from summer 1999 would probably represent the second stage of the colonization process, involving the establishment of a surplus population.

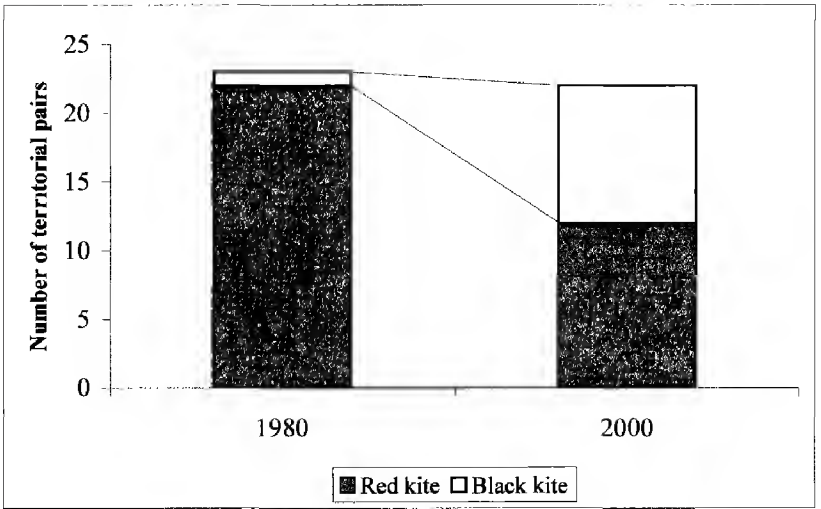


Figure 4. Number of territorial Black and Red Kite pairs recorded in 1980 and 2000 in central Sicily, Italy.

Apart from the process of recolonization following local extinction caused by human persecution or pesticides, relatively few status changes have been recorded in raptors (Newton 1979). For example, Newton described the sedentarization of Swainson's Hawks (*Buteo swainsoni*). Moreover, the regular year-long presence of the formerly summer breeding Red Kite populations in France (Valet 1975), Switzerland (Juillard 1977), and Germany (George 1996 and references therein) is well known. These authors suggest the Red Kite sedentarization was related to the increasing occurrence of mild winters without snow that allowed accessibility to the local food supplies (e.g., more active prey, development of garbage dumps).

The first overwintering of Black Kite in central Sicily occurred during four years (1987–90) of severe drought and warm winters. In the same period, the wintering of Lesser Kestrels (*Falco naumanni*) in the area was also recorded (Sarà 1996a). The sedentarization of Black Kite may have been initiated by such climate change, and one can speculate that global warming, increasing the mean local winter temperatures in recent decades, may have favored the extension of the species' wintering range northward.

The colonization process since 1980 may have also been facilitated by the recent decline of the local Red Kite population (Fig. 4). The ecological niche left empty by declining resident Red Kite pairs has likely been occupied by the Black Kite, a new colonizer expanding its range northward.

Human persecution and poor land management (e.g., summer fires, poisoning, and shooting) resulting in direct kite mortality and lower prey populations are probably the main factors currently limiting the density of Black Kites in Sicily (Sarà 1996b) and, thus, slowing the colonization process in the last 50 years.

RESUMEN.—Describo la colonización de los milanos negros (*Milvus migrans*) en Sicilia. Los antiguos ornitólogos del siglo IX consideraban esta especie como ocasional y rara en Sicilia. Comúnmente, el milano negro ha sido clasificado como la segunda especie más común observada en el estrecho de Messina en primavera y es inclusive más abundante durante la migración de otoño. Hábitats adecuados de ambientes acuáticos y de espacios abiertos están disponibles a lo largo de la ruta migratoria del milano, lo cual pudo haber favorecido la coloniza-

ción. Esta especie se encuentra reproduciéndose y permaneciendo durante el invierno en un área aproximada de 100 km² localizada en el centro de Sicilia. El primer registro reproductivo confirmado fue reportado en 1979, luego prosiguió una colonización más amplia. La estadía tardía fue registrada durante los censos vehiculares en 1987–92, estos milanos no fueron observados durante las investigaciones previas (1977–80). En la porción central del área del área de estudio, un individuo fue observado entrando a un dormitorio del milano rojo (*Milvus milvus*) durante el invierno de 1990–91 y un pequeño grupo de cuatro a siete milanos negros es regularmente observado ahora. La última fase del proceso de colonización fue el establecimiento de un dormitorio de verano sobre un vertedero de basura, el cual aumentó de una media de 6.6 a 19 individuos no reproductivos en 1998–2001. La población total hacia finales de Agosto es de 50–60 aves.

[Traducción de César Márquez]

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LETTERS

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GYRFALCON COLOR VARIATION

A literature survey dealing with Gyrfalcons (*Falco rusticolus*) reveals that references to the various Gyrfalcon color variants as *morphs* is becoming more common (e.g., Sibley 2000, *The Sibley guide to birds*, Alfred A. Knopf, Inc., New York, NY U.S.A.). Such references often make the assumption that the three common Gyrfalcon color groups are comparable to the true red and gray morphs of the Eastern Screech-Owl (*Otus asio*) and to the blue and Snow Goose (*Chen caerulescens*) morphs. In my opinion, this is not correct.

Ford (1945, *Biol. Rev.* 20:73–88), emphasized that morphs must first be phenotypically distinguishable with discontinuities in the phenotype. He also stated that polymorphism must not be used to include continuous or quasi-continuous variation.

Huxley (1955, *Acta Int. Ornithol. Congr.* 11:309–328) proposed use of the term *morphism* to denote genetic polymorphism opposed to other kinds of polymorphism (e.g., seasonal, cyclic, geographic). He referred to Ford's definition of genetic polymorphism as the coexistence in one interbreeding population of two or more sharply distinct and genetically-determined forms. Further, Huxley pointed out that the least abundant form should be present in numbers too great to be due solely to recurrent mutation, and proposed that such forms be called *morphs*. Huxley also suggested removal of the adjective “*sharply*” from the definition to accommodate rare cases of continuous polymorphism. He argued that in continuous morphisms, such as in the sea-plaintain (*Plantago maritima*), there are no sharp discontinuities, and the excessive genetic variability constituting the continuous polymorphism is maintained by selection. He stressed the fact that every morphism must involve some balance of selective advantage and disadvantage, some underlying genetic basis, and that its discontinuities must be determined either genetically or developmentally.

The Gyrfalcon would be an example of *continuous polymorphism* if that were acceptable terminology. I suggest that the term *continuous polymorphism* is a contradiction that should be avoided.

It has been established for many years that Gyrfalcon color variation extends in a continuum from white to almost black, although most birds are classed as either white, gray, or dark (Th.N. Krabbe 1934, *Medd. Dan. Naturh. Foren.* 98:4–107; see Plates III to VI). In a study of 205 specimens collected from European Russia across to eastern Siberia, Ellis et al. (1996, *J. Raptor Res.* 26:81–88) found the same continuum. They classified the birds as *color variants*, and found that climate was a better predictor of color than latitude; the area with the highest percentage of white birds was eastern Siberia.

Clum and Cade (1994, *In* A. Poole and F.B. Gill [EDS.], *The birds of North America*, No. 114. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC U.S.A.) state the stripe on white birds, when expressed, consists of a few dark streaks next to the shafts of the feathers, giving a kind of speckled appearance. Clum and Cade also asked “what level of plumage variation among *morphs* is justified?” This use of the term *morph* was an error (T. Cade pers. comm.).

In North America, there is a coarse progression in the ratio of light birds to dark birds from northeast to west; birds of northern Greenland and the eastern high arctic are usually white, those of the central arctic are usually 50 white:gray, and those in the Yukon and Alaska are mainly gray, a few dark. At Ungava Bay, however, “the whitest and blackest varieties breed together in the same area along with every kind of intermediate” and there are white birds in western Alaska (Cade 1960, *Univ. Calif. Publ. Zool.* 63:151–290). In Eurasia there are no white birds in Fennoscandia and western Russia, but the occurrence of white birds increases eastward until they make up ca. 50% of the population in northeastern Siberia and Kamchatka (Cade et al. 1998, *J. Birds Western Palearctic* 2:1–25).

In the Lower Kolyma, northeastern Siberia, pairs of white Gyrfalcons were limited to the maritime coastline with cliffs, whereas pairs of gray birds were limited to the timberline. The white Gyrfalcons were preying on ducks and waders, while the gray Gyrfalcons were eating grouse (*Lagopus* sp.). The hunting strategy of the two color variants was also different (E. Potapov pers. comm.).

Because Gyrfalcons do not exhibit two or more distinct forms, the various Gyrfalcon color variants are not morphs according to Huxley's definition. Why then do we see more and more references to Gyrfalcons as *morphs* in bird

guides and scientific papers? The error stems from at least two sources. Huxley, apparently, was under the impression that all Gyrfalcons fell into one of three color categories; therefore, he referred to them as *morphs*. Second, some authors have expanded the original definition of *morph*.

“Morph—term used for recognizably different forms of a species, usually color related. Color morphs are dark, rufous, and light.” (Wheeler and Clark 1995, *A photographic guide to North American raptors*, Academic Press, San Diego, CA U.S.A.).

Frank Beebe (pers. comm.) agrees that the concept of three Gyrfalcon morphs is misleading to some ornithologists and birdwatchers. For example, at some locations white Gyrfalcons have all-white tails, while at other locations they have conspicuously barred tails.

A few field guides refer to the white, gray, and dark *phases* of the Gyrfalcon. For some the term *phase* implies a change with time, and sometimes it refers to synchronization; therefore, its use with reference to Gyrfalcons is not appropriate. It is akin to referring to *blue phase* Rock Doves (*Columba livia*).

What is the appropriate terminology for Gyrfalcons? Cade (pers. comm.) now prefers *color variants*. Thomson (1964, [Ed.], *A new dictionary of birds*, McGraw-Hill, New York, NY U.S.A.) suggested the term *form*, and provided the following definition:

“Form, in taxonomy, a loose or deliberately neutral term for a species or sub-division thereof, non-committal as regards rank or status to be assigned to it.”

This problem in semantics is best resolved by understanding the causes for the unusual color variation. Cade (pers. comm.) hypothesized that the three broad color groups are a result of geographic isolation in Pleistocene refugia during the past 100 000 years or so. He believes that the white birds evolved in isolation in the Ellesmere Island–north Greenland refugium. A melanistic form may have evolved in another refugium around Labrador; while the original or ancestral gray gyrs were restricted to habitats south of the continental ice sheets in North America and Eurasia. When the ice retreated, the breeding ranges of the various forms merged and, because no reproductive isolating mechanisms had evolved, the three color variants (originally geographic in origin), have freely interbred to produce the present distribution and range of variants we see in the Gyrfalcon’s plumage.

In any case, it is clear that there is a color continuum in Gyrfalcons, and not in screech owls, and that the term *morph* is being used for both patterns of morphological variation. I suggest the term *morph* is most appropriate for discontinuous variants and not the Gyrfalcon.

I would like to thank T.J. Cade for his assistance over the years, and E. Potapov and referees D. Bird, A. Jenkins, and P. Koskimies for their helpful comments.—**Ian Flann, 1067 Wiseman Crescent, Ottawa, Ontario, K1V 8J3, Canada.**

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TWO WHITE-TAILED SEA EAGLES (*HALIAEETUS ALBICILLA*) COLLIDE WITH WIND GENERATORS IN NORTHERN GERMANY

Recently, the issue has arisen whether wind generator structures may have a significant impact on bird populations. The sustainable use of wind energy has led to a substantial increase in the number of wind-power plants in Germany. In the last 5 yr, the number of wind turbines has doubled. In the year 2000, wind power plants generated more than 6113 MW power, or 2.4% of the total energy power consumption in Germany. Especially windy areas in the northern parts of Germany, where large numbers of waders and water birds live, are favored by this development. Studies on these bird groups revealed that wind power plants have a substantial effect on the behavior of these birds through disturbance, harassment, and loss of habitat, rather than the direct mortality due to collisions (Exo 2001, *Natur und Landschaftsplanung* 33:323).

The White-tailed Sea Eagle (*Haliaeetus albicilla*) is still listed as a threatened species in the red data book of Germany (Witt et al. 1998, In: Binot et al. *Rote Liste gefährdeter Tiere Deutschlands*, Bundesamt für Naturschutz, 40–47), although the population has doubled in the last 10 yr, reaching 381 territorial pairs in 2001. The core population that has

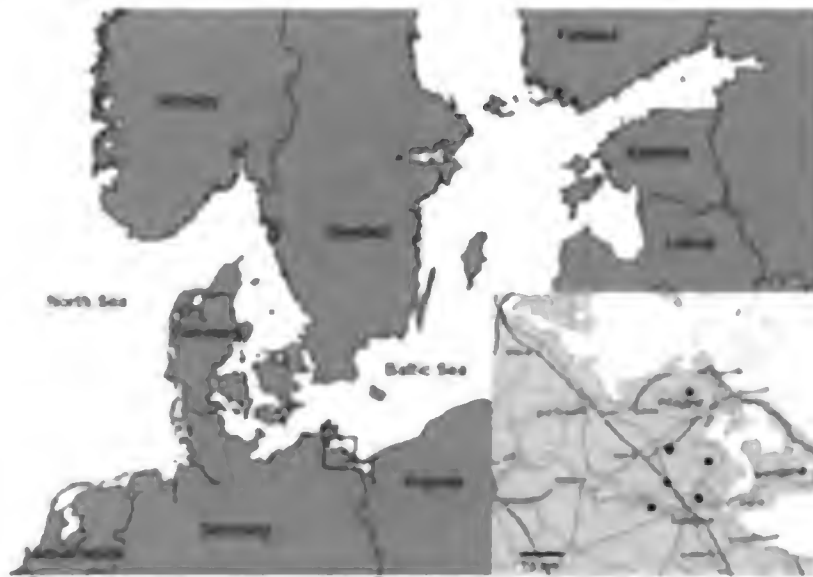


Figure 1. Map of the Baltic Sea with its surrounding states. Inset showing strike locations; i.e., wind power plants (asterisks) and breeding sites (closed circles) in northeastern Germany.

supported the increase and expansion of this eagle population lies within the federal state of Mecklenburg-Western Pomerania in northwestern Germany with 174 territorial pairs in 2001 (Kollmann et al. 2002, *Corax* 19:1–14).

A White-tailed Sea Eagle was found dead in a wind power plant in northeastern Germany in the federal state of Mecklenburg-Western Pomerania on 26 January 2002. The park consisted of two rows with 20 single turbine towers, each 65 m tall with a rotor of 41 m in diameter (maximum height = 85 m) and is located north of the town of Wolgast in the coastal area of the Baltic Sea (Fig. 1). Prior to the collision, it was very windy, with mean wind speeds between 30 and 40 km/hr and maximum speeds of 90 km/hr. Necropsy at the Institute for Zoo and Wildlife Research (IZW), Berlin, revealed a displacement of the thoracic vertebral column with fractures of two vertebrae and several broken ribs on both sides. The adult female eagle was in very good body condition and no signs of a disease were identified. The accident may have been caused by a squall, which took the eagle into the propeller while it was hunting.

Another White-tailed Sea Eagle was directly observed when hit by a propeller of a wind generator in a plant consisting of seven generators of the same type mentioned above and located in one row in Mecklenburg-Western Pomerania near the town of Anklam, also in the coastal area of the Baltic Sea on 1 April 2002 (Fig. 1). Residents walked near this wind power plant in sunny weather (17–18°C) when they heard a dull noise at 0920 H CET; they turned and saw the eagle falling to the ground. No behavior to avoid the strike by the rotor was observed, because the event was first recognized when the sound of the collision was heard. The eagle was a subadult 4-yr-old male and it was brought injured to a veterinarian who diagnosed a multiple fracture of the right radius and ulna. The veterinarian attempted to align the bones, but was unsuccessful. Subsequently, the bird was euthanatized due to the development of the severe osteomyelitis in the right ulna and radius. The eagle was ringed in June 1998 in an eyrie on the island of Usedom ca. 25 km northeast of the location where the bird collided with the wind turbine.

This is the first report of White-tailed Sea Eagles being killed by wind turbines. Previous studies on causes of death of White-tailed Sea Eagles in Germany did not mention casualties by wind generators (Oehme 1966, *Falke*, 13:40–47; Struwe-Juhl and Latendorf 1997, *Vögelwelt*, 118:95–100; Krone et al. *in press*, *Proc. Conf. Sea Eagle 2000*, Björko, Sweden).

The northeastern part of the federal state of Mecklenburg-Western Pomerania borders on the Baltic Sea, with waters draining from the island of Usedom and the Peene stream from the mainland in close proximity. The waters are rich in fish and waterfowl, providing a food source for several breeding pairs of eagles, and supporting high numbers of migrating and wintering individuals. The landscape largely consists of cultivated areas interspersed with patches of deciduous and mixed forests. The climate of the region is strongly influenced by the Baltic Sea resulting in a delayed spring, relatively cold and wet summers and mild winters with little snow. The mean temperature of the year is 8.1°C with a mean rain fall of 584 mm. The preceding wind raptor direction is southwest.

Incidents such as these are likely to occur in areas with large raptor populations and a high prey base for raptors. Estep (1989, *Unpubl. Rep. California Energy Commission, Sacramento, California*) documented collisions with wind turbines by 72 raptors of seven species at two Wind Resource Areas (WRA) in California (Altamont Pass and Tehachapi Pass). The Golden Eagle (*Aquila chrysaetos*) and the Red-tailed Hawk (*Buteo jamaicensis*) were the most frequently reported species, comprising 86% of the collision incidents. Fatalities were reported year round, affecting local as well as migrating and wintering birds. During a 4-yr investigation of 179 radio tagged Golden Eagles, 61 deaths were recorded, of which 23 were caused by wind turbine blade strikes. Non-territorial Golden Eagles often visited the WRA,

whereas breeding eagles rarely entered the WRA (Hunt et al. 1999, Report to the National Renewable Energy Laboratory, XAT-5-15174-01, XAT-6-16459-01, Predatory Bird Research Group, University of California, Santa Cruz, CA U.S.A.). However, a review of different sources of avian collision mortality in the United States indicated that death associated with wind plants is much lower than other sources of collision mortality (Erickson et al. 2001, National Wind Coordinating Committee, Washington, DC U.S.A.). The high levels of raptor mortality at Altamont were explained by large raptor populations, a high prey base for raptors, and the large size of the wind plant. A study performed in the Campo de Gibraltar region in Spain, a major passway of bird migration to Africa, also demonstrated the severe impact of a wind farm on large birds (Montes and Jaque 1995, Summary of final report, Soc. Espan Ornitol.). Of 82 birds found after collisions with wind generators, five raptors were affected, of which the Griffon Vulture (*Gyps fulvus*) was most common (43 collisions).

In contrast to the wind power facility in California, the wind power plants in Mecklenburg-Western Pomerania are much smaller, but this is an important area for migrating and wintering White-tailed Sea Eagles in the Baltic Sea region. Systematic studies on wind turbines to examine their full range effects on behavior, reproductive success, and mortality of raptors are strongly needed for Germany, as there are plans to enlarge the total energy generated by wind in Germany in the near future.

We are grateful to F. Seemann from the Mueritz Museum Waren and to the editor and anonymous referees for their helpful suggestions.—**Oliver Krone, Institute for Zoo and Wildlife Research, P.O. Box 601103, D-10252 Berlin, Germany; e-mail address: krone@izw-berlin.de and Christian Scharnweber, State Office for Environment and Nature, Dorfstr. 86, D-17392 Putzar, Germany.**

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TALON-LOCKING IN THE RED-TAILED HAWK

Talon-locking by two Red-tailed Hawks (*Buteo jamaicensis*) in flight is widely accepted (e.g., Ferguson-Lees and Christie 2001, *Raptors of the world*, Houghton Mifflin, Boston, MA and New York, NY U.S.A.), although it appears to have been well described in the literature only once (Warren 1890, Report on the birds of Pennsylvania, 2nd Ed., Harrisburg, PA U.S.A.), who observed it during fall migration. He was cited by Bent (1937, Life histories of North American birds of prey, Part 1, U.S. Natl. Mus. Bull. 167, Washington, DC U.S.A.) and Palmer (1988, Handbook of North American birds, Vol. 5, Diurnal raptors, Yale Univ. Press, New Haven, CT U.S.A.), who also briefly described the behavior seen in the spring, which he interpreted as one bird being a territory holder and the other an interloper. Palmer was cited by Preston and Beane (1993, in A. Poole and F. Gill [Eds.], *The birds of North America*, No. 52 The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC U.S.A.). Voelker (1969, *Loon* 41:90–91) witnessed courting birds locking bills in flight and falling to the ground, and he quotes another observer who reported courting birds locking bills or feet and falling to the ground. Both of those observations were made in March.

On 24 January 2000, two Red-tailed Hawks (*Buteo jamaicensis calurus*) were recovered under an electrical transformer near the entrance to the National Guard Armory in Santa Fe, New Mexico by the Public Service Company of New Mexico. They had been electrocuted and partially burned; all four of their talons were locked together. One was in normal definitive plumage, the other was a dark-phase bird with a sub-definitive banded tail. Both birds were females with ovaries measuring 8×20 and 8×15 mm, respectively. They were too burned to be preserved.

This incident of talon-locking between female Red-tailed Hawks occurred in January, suggesting aggressive interaction, in which one hawk was attempting to displace another hawk that was perched on the pole with a transformer. With talons locked the two birds made contact with two wires resulting in electrocution.

I wish to thank Anne Sanchez of the Public Service Company of New Mexico for presenting these birds to the Museum of Southwestern Biology, and the reviewers of this note for their helpful suggestions.—**Robert W. Dickerman, Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM 87131 U.S.A.; e-mail address: bodbickm@unm.edu**

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